DOCUMENT RESUME

ED 200 400 SE 033 912

AUTHOR	White, Arthur L., Ed.; Novak, John A., Ed.
TITLE	National Association for Research in Science Teaching Annual Meeting, Abstracts of Presented Papers (54th, Grossinger's in the Catskills, New York, April 5-8, 1981).
INSTITUTION	ERIC Clearinghouse for Science, Mathematics, and Environmental Education, Columbus, Ohio.; National Association for Research in Science Teaching.
SPONS AGENCY	National Inst. of Education (ED), Washington, D.C.
PUB DATE	81
CONTRACT	400-78-0004
NOTE	221p.
AVAILABLE FROM	Information Reference Center (ERIC/IRC), The Ohio State Univ., 1200 Chambers Rd., 3rd Floor, Columbus, OH 43212 ($4.00).
EDRS PRICE	MF01/PC09 Plus Postage.
DESCRIPTORS	Cognitive Development; *Conference Papers; Elementary Secondary Education; Higher Education; Learning; Professional Associations; *Science Education; Science Instruction; Teacher Education
IDENTIFIERS	National Assn for Research in Science Teaching; *Science Education Research

ABSTRACT

Presented are abstracts for most of the papers presented at the 54th annual conference of the National Association for Research in Science Teaching (NARST), held at Grossinger's in the Catskills, April 5-8, 1981. Papers relate to learning in museums, classroom behavior, cognitive development, male-female differences, diagnostic testing, research methods, and other topics. (CS)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED200400

U S DEPARTMENT OF HEALTH
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

NATIONAL ASSOCIATION

FOR RESEARCH IN SCIENCE TEACHING

Grossinger's in the Catskills

April 5-8 1981

ERIC Clearinghouse for Science, Mathematics
and Environmental Education
The Ohio State University
College of Education
1200 Chambers Road, Third Floor
Columbus, Ohio 43212

SE 033 912

PREFACE

The ERIC Clearinghouse for Science, Mathematics, and Enviromental Education has cooperated with the National Association for Research in Science Teaching to provide abstracts of most of the papers presented at the 54th annual conference at Grossinger's in the Catskills April 5-8, 1981.

All persons who had papers or symposia accepted were invited to submit abstracts for inclusion in this publication. Some editing was done by the ERIC staff to provide a general format for the abstracts. Special recognition should be given to Dr. Stanley L. Helgeson and Dr. John W. Renner and the NARST Program Committee who obtained the abstracts and organized the program.

Many of the papers will be published in journals or be made available through the ERIC system. These will be announced through Resources in Education, Current Index to Journals in Education, and other publications of the ERIC system.

Arthur L. White and John A. Novak
Editors

This publication was prepared with funding from the National Institute of Education, U.S. Department of Education under contract no. 400-78-0004. The opinions expressed in this report do not necessarily reflect the positions or policies of NIE or U.S. Department of Education.

Preface ii

PAPERS PRESENTED AT THE CONFERENCE

CONCURRENT SESSION A

Session A-1. Paper Set: Learning in Informal Settings-Naturalistic and Experimental Museum Studies

Environmental Problems and Issues in Museum Research
John J. Koran, Jr. and Edward A. Munyer. 1

Studying Modeling in Museums
Lynn D. Shafer; Jeff R. Lehman; John J. Koran, Jr.; Edward A. Munyer; and Mary Lou Koran 2

Studying Mathemagenic Behavior in Museums
Lynn D. Shafer; Jeff R. Lehman; John J. Koran, Jr.; Edward A. Munyer; and Mary Lou Koran 3

Discussion, Analysis, and Synthesis
Mary Lou Koran and William G. Holliday

Session A-2. Measurement Techniques

The Use of the State-Trait Anxiety Inventory in the Measurement of Anxiety About Teaching Science in Preservice Elementary Teachers
Mary Westerback. 4

A Scalogram Analysis of Two Measures of Concept Generalization
Walter E. Lowell and Kemal bin Abdullah. 5

Preparation and Validation of a Videotaped Test of Conservation Suitable for Grade Six Students in Jamaica
Patricia A. Isaacs 6

Session A-3. Symposium: Research Needed to Better Understand Developmental Approaches to Instruction and Curriculum Development

Michael R. Abraham and John W. Renner. 7

Session A-4. Classroom Behavior Analysis

Analyzing Arguments in Classroom Discourse: Can Teachers' Questions Distort Scientific Authority?
Thomas L. Russell. 8

Student Behaviors in Desegrated Junior High School Science Classrooms
Bessie A. Stanback 10

The Effects of Behavior Model Analysis on Teachers' Behaviors During Science Activity Lessons
P. Ann Miller. 12

CONCURRENT SESSION B

Session B-1. Paper Set: Patterns of Reasoning

Patterns of Reasoning: Controlling Variables
William Capie; Kenneth G. Tobin; and Roger Newton. . . 13

Patterns of Formal Reasoning; Probabilistic Reasoning
Kenneth G. Tobin; William Capie, and Roger Newton. . . 15

Patterns of Reasoning: Proportional Reasoning
Roger Newton; William Capie; and Kenneth G. Tobin . . 17

Patterns of Reasoning: Correlational Thinking
Danny L. McKenzie and Michael Padilla. 19

Session B-2. Meta Analysis

The Major Questions Addressed by the Extant Science Education Research: A Map for Meta-Analysis
Ronald Anderson; Stuart R. Kahl; Mary Lee Smith, Russell H. Yeany; and Gene V Glass 21

A Meta-Analysis of the Relationship Between Science Achievement and Science Attitude: Kindergarten Through College
Victor L. Willson. 22

Session B-3 Panel: Building a Base of Community Support for Science Education

William C. Ritz; Kenneth W. Dowling; Floyd E. Mattheis Herbert D. Thier; and Charles W. Wallace. 23

Session B-4. Learning and Instruction

Relationship Between Abstract Reasoning, Instruction, and Achievement on a Physiology Unit Studied in Tenth Grade Biology
Eugene L. Chiappetta 24

The Effect of Instruction Using Students' Prior Knowledge on Conceptual Change
M. G. Hewson 25

Session B-5. Symposium: Investigations of Male-Female Differences in Science Performance: Learner Characteristics or Learner Experiences?

Beverly Birnes; Marcia C. Linn; Steven Pulos; Elizabeth K. Stage and Wayne W. Welch 26

CONCURRENT SESSION C

Session C-1. Paper Set: Sex Differences in College Students

The Differences Among Science and Humanities Males and Females
Dale R. Baker. 27

College Physics Achievement: Do Females and Males Differ?
David Van Harlingen. 29

Sex Differences in College Level General Biology
Veronica Mondrinos 30

Session C-2. Teacher Performance

Performance Assessment of Elementary School Science Teachers
Dale G. Merkle 32

The Predictors of Science Teaching Performance in Elementary School Teachers
Mildred R. Green 33

A Factor Analytic Study of Secondary Science Teacher Competencies Within Which Growth is Perceived as Important by Science Teachers, Supervisors, and Teacher Educators
H. Craig Sipe and Bruce Tulloch. 34

Session C-3. Discussion: Activities of the NARST Research Committee

Arthur L. White; Claudia Douglas; David J. Harmon; and Linda DeTure 36

Session C-4. Science Curriculum Analysis

Attitude Measurement in an Innovative Curriculum
Peter E. Pezaro. 37

The Analysis of Science Curriculum Policies
Graham W. F. Orpwood 38

An Analysis of Selected National Elementary Science Curriculum Projects Using Ralph W. Tyler's "Basic Principles of Curriculum and Instruction" as a Standard of Comparison
Richard E. Willett 39

Session C-5. Symposium: Investigations of Male-Female Differences in Science Performance: Learner Characteristics or Learner Experiences?

Continuation of Session B-5 26

CONCURRENT SESSION D

Session D-1. Paper Set: Learning Research

An Investigation of the Role of Piagetian Mental Operations on Earth Science Concept Attainment in a Differentiated Instruction Model for Concrete and Formal Level Subjects
Gabriel M. Ziccarelli and G. W. Moser. 42

A Linear Path Model of Delayed Prose Recall of a Lecture on Radiation Effects
G. W. Moser and Helen M. Loughner. 43

The Discriminability of Student Traits and Energy Opinions for Final Chemistry Course Grades
Helen M. Loughner and G. W. Moser. 45

The Discriminability of Mathematics and Science Achievement by Music Interests and Practices of Vocational Education Students
Edward T. Hrabal and G. W. Moser 47

Session D-2. Information Retrieval

Representing the Substantive Structure of Disciplines
Fred N. Finley 48

Young Adults Trust in Information Sources About Science Policy Issues
Alan M. Voelker. 50

Preparing and Using Data Tapes and Machine Readable Users Guides: A New Resource for Science Education Research
James T. Robinson. 51

Session D-3. Research Review

NARST-ERIC/SMEAC Review of Research in Science Education-1979
David P. Butts 52

Session D-4. Meaningful Learning

The Selective Facilitiative Effects of Concrete Organizers and Abstract Organizers on Targeted Achievement Groups' Learning
Edward E. Jones. 53

The Effects of Degree of Concept Relatedness of Instruction and Locus of Control Orientation on the Meaningful Learning Achievement of High School Biology Students
Jacqueline D. Sherris. 55

Session D-5. Research Methods Seminar/Workshop: Nonparametric Statistical Techniques for Science Educators
Robert D. Sherwood. 57

CONCURRENT SESSION E

Session E-1. Trends in Science Education

Trends with Respect to Science Teacher Education, Faculty, and programs
John E. Penick; Rodger Bybee; and Ertle Thompson . . . 58

Follow-up of the NSF Status Study of Graduate Centers of Science Education in the United States, 1960-80
Edward L. Pizzini; Kenneth W. Dowling; Robert E. Yager and Charlotte Purnell. 59

Characteristics of 168 Faculty Members at 35 Major Graduate Centers for Science Education
Robert E. Yager; Eric E. Zehr; and Rodger Bybee. . . . 60

Session E-2. Sex Related Differences and Roles

An Analysis of the Relationship of Students' Self Concepts in Science and Their Science Achievement, Mental Ability, and Gender
Burt A. Sellers. 61

Sex-Role Stereotypes, Interest In Science, and Responses of Sixth-Graders to Scientists/Technologists on T.V.'s "3-2-1 Contact"
Marcia Kaplan Rudy 63

Cognitive Correlates of Sex-Related Differences in Performance in College Biology
Daniel Dobey and William Doody 65

Session E-3. An Hour with the Journal Editor

James A. Shymansky. 67

Session E-4. Cognitive Development

Cognitive Style and the Effects of Two Instructional Treatments on the Acquisition and Transfer of the Ability to Control Variables: A Longitudinal Study
Barbara M. Strawitz. 68

An Analysis of the Range of 2B and 3A Responses to Three Inhelder Tasks
Walter A. Farmer 70

Session E-5. Research Methods Seminar/Workshop: Nonparametric Statistical Techniques for Science Educators

Continuation of D-5 57

CONCURRENT SESSION F

Session F-1. Paper Set: Logical Reasoning

An Error Analysis of Responses to a Test of Propositional Logic
Michael D. Piburn and Morris A. Enyeart. 72

The Development of the Ability to Use Propositional Operators
William Martin and Walter Lockwood 73

Logical Operations and Achievement in Community College Students
Walter Rothaug; George Pallrand; and David Van Harlingen 75

The Growth of Propositional Logic Ability During Junior High School Years
Morris A. Enyeart and Michael D. Piburn. 77

Session F-2. Prose Analysis

Using Questions to Focus Students' Attention on Non-Prose Science Materials
William G. Holliday and Garth D. Benson. 79

The Relationship of Prose Statements Assessing the Energy Crisis and the Cognition of Figural Perception Transformations
David P. Kielbowick. 81

Research Approaches for Analyzing Free Prose Data Embedded in Curriculum
David D. Carbonara 82

Session F-3. College Science Students

Who Translates Research into Practice? A Look at the Personality Profiles of Science Education Engineers
John E. Lutz 83

Projective Spatial Reasoning of Undergraduate College Students
Linda J. Kelsey. 84

The Effects of Selected Student Characteristics and College Learning Environment on Science Process Skills and Information Acquisition
John E. Penick and Gerry Haukoos 86

Session F-4. Science Teaching Laboratories

Objective and Continuous Assessment of Student Performance in the Physics Laboratory
Uri Ganiel and Avi Hofstein. 87

A Descriptive Instrument for Use in Investigating Science Laboratories
Michael R. Abraham 89

A Laboratory Study of Physics Teaching in the Egyptian General High School in Light of Recent International Trends
Ahmed Khalil Mohamed Hassan. 90

Session F-5. Research Seminar/Workshop: Trend Analysis Using Microcomputers
Carl F. Berger 93

CONCURRENT SESSION G

Session G-1. Paper Set: Diagnostic Testing

The Influence of Voluntary Diagnostic Testing on the Science Achievement of University Students
Wenda J. Adams; Russell H. Yeany; and Edwin A. Helseth 94

The Influence of Voluntary Diagnostic Testing on the Science Achievement of University Students: A Replicated Study
Russell H. Yeany; Edwin A. Helseth; and Wenda J. Adams 97

Predicting Science Achievement of University Students on the Basis of Selected Entry Characteristics
Edwin A. Helseth; Russell H. Yeany; and Wenda J. Adams 100

Session G-2. Cognitive Development

The Acquisition of Formal Reasoning Ability via a Neo-Piagetian Treatment
William Lamb and Marianne Betkouski. 102

Teaching Formal Reasoning in a College Biology Course for Pre-Service Teachers
Anton E. Lawson. 104

Predicting the Piagetian Cognitive Levels of Teacher Education Students at the Pennsylvania State University
Hassan H. Zeitoun and H. Seymour Fowler. 106

Session G-3. Science Needs, Interests, and Literary Surveys

The Determination of the Scientific Literacy of the Students in Twelve Specific Counties in Georgia
Constance T. McNeill and David P. Butts. 107

Science Interest of Middle and Secondary School Students in Utah
J. Hugh Baird and Rueven Lazarowitz. 108

Science Needs Assessment: A Statewide Approach
Piyush Swami; Lawrence L. Gabel and Stanley L. Helgeson 110

Session G-4. High School Science Methodology

Facilitating Problem Solving in High School Chemistry
Dorothy L. Gabel and Robert D. Sherwood. 111

The Effects of the Mastery Paradigm on Summative Performance in a High School Biology Laboratory Course
William S. Kushner 113

Session G-5. Research Seminar/Workshop: Trend Analysis Using Microcomputers

Continuation of Session F-5 93

CONCURRENT SESSION H

Session H-1. General Research

A Report on 1977-80 Project LEO Studies of Quantitively-Defined Science Teaching Strategies
Charles C. Matthews; Charlie L. Ray; and Dorothy Schlitt. 115

A Comparative Laboratory Study of the Effects of Lower Level and Higher Level Questions on Students' Abstract Reasoning and Critical Thinking in Two Non-Directive High School Chemistry Classrooms
Charlie L. Ray; Charles Matthews; and Dorothy Schlitt. 117

Session H-2. Round Table: The Frequencies and Origins of Scientific Misconceptions

Richard J. Trembath and James P. Barufaldi. 119

Session H-3. Teacher Behavior

The Comparative Effects of Congruent and Incongruent Teacher Verbal Behavior on Higher Level Learning Outcomes of Secondary Biology Students During Discovery/Inquiry Laboratories
James A. Botti and H. Seymour Fowler 121

Effects of Curricula on Search Behaviors Modeled by Science Teachers
John T. Wilson 123

A Case Study Example of a Beginning Teacher's Use of Curriculum Materials and the Potential Outcomes for Students
Brent Kilbourn 124

Session H-4. General Research

The Cognitive Developmental Level of Elementary School Students in Trinidad and Tobago
Pamela Fraser-Abder and H. Seymour Fowler. 125

Using the Intensive Time-Series Design for Assessing Learning of Crustal Evolution
Victor J. Mayer and Carlos A. Rojas 127

Session H-5. Research Seminar/Workshop: Determining the Power of Statistical Tests and Sample Sizes for Research Studies

Rosalie Grant 129

CONCURRENT SESSION I

Session I-1. Outstanding Paper

Session I-2. Judgment and Decision Analysis

A Model of Class Inclusion Development Based on Subjects' Verbal Justifications
Jean Sindhikara. 131

Objective Measures of Cognitive and Moral Judgment Level in Bioethics
John Finley and Cheri M. Taylor. 132

An Investigation of the Relationships Between Students' Self Concept, Mental Maturation, Degree of Open Mindedness, and the Numerical Values They Assign to Indefinite Quantitative Words and Expressions
Pastor R. Rojas; Ninoska R. Rojas; and Michael Duffy . 134

Session I-3. Symposium: Formal Operational Reasoning: Format, Content, and Intervention
Jane Bowyer; Robert Karplus; Marcia C. Linn; Steven Pulos; and Elizabeth K. Stage 136

Session I-4. General Research

Applications of Scientific and Mathematical Processes Using Microcomputers Part II: Sex and Age Correlates to Estimation
Carl F. Berger 137

Thirty Studies Involving the "Scientific Attitude Inventory": What Confidence Can We Have in This Instrument?
Hugh Munby 138

Session I-5. Research Methods Workshop: A Quantitative Procedure for Treatment Verification in Science Teaching Research

William H. Leonard 140

CONCURRENT SESSION J

Session J-1. General Research

An Investigation of Relationships Between Cognitive Preference Orientation and Jungian (MBTI) Personality Types of Eighth-Grade Science Students
John A. Novak and Burton E. Voss 142

Learning from Science Text Aided by Diagnostic and Prescriptive Instructional Strategies Derived from Information-Processing Theory
Pierce Farragher and Michael Szabo 145

Session J-2. Teacher Training

A Comparison of Pupil Control Ideology of Science and Non-Science Secondary Student Teachers
Dan R. Jones. 146

The Effects of a One-Day Energy Workshop on Science Teachers' Attitudes Toward Energy-Related Topics
David L. Dunlop and Frank Fazio 148

The Effect of Reasoning Workshops on the Teaching Strategies of Secondary Science Teachers
Anne Lombard. 150

Session J-3. An Hour with Past Presidents

Session J-4. Achievement

The Effect of an Explaining Module on Preservice Elementary Science Teachers' Knowledge of Explaining Teaching Behavior and Student Achievement
Joseph P. Riley II 152

An Emperical Determination of Concepts Contributing to Successful Science Task Performance: A Study of Mineral Classification
William L. Yarroch and Fred N. Finley 154

Session J-5. Research Methods/Workshop: A Quantitative Procedure for Treatment Verification in Science Teaching Research

Continuation of Session I-5 140

CONCURRENT SESSION K

Session K-1. Curriculum Analysis

Tactile Apprehension in Young Children--Development and Implications for Design of Science Curricula
Dennis W. Sunal and Cynthia S. Sunal. 155

Evaluating Science Curricula: Relating Educational Process to Product
James D. Ellis. 157

Patterns in the Use of Elementary School Science Materials: An Observational Study
Charles W. Anderson 158

Session K-2. Visual and Spatial Relationships

Relationship Between Locus of Control and the Development of Spatial Conceptual Abilities
Herbert G. Cohen. 160

Visual Testing and Visual Instruction in High School Biology
Michael Szabo; Hermes T. DeMelo: and Frances Dwyer . . 163

Comparison of High and Low Spatial Males and Females on Selected Science Concepts
Carole Ann Camp. 165

Session K-3. College Level Science

College Level Physical Science for Non-Majors
John P. Schellenberg and Paul E. Bell 167

Effect of Experience with Investigative Biology on College Students' Views of Scientific Method and Knowledge
Margaret Waterman 168

Operational Determinants for Academic Promotion in Undergraduate Science Departments
Gloria J. Dyer. 169

Session K-4. Instrument Development

Validation of the Test of Integrated Science Process Skills
James R. Okey; F. Gerald Dillashaw; and Charles F. Porter 171

Designing a Likert-type Scale to Assess Attitude Toward Energy Conservation
Thomas R. Koballa, Jr. 173

Session K-5. Research Seminar/Workshop: Assessing Pupil Engagement in Learning Activities

William Capie and Kenneth G. Tobin 175

CONCURRENT SESSION L

Session L-1. Attitudes and Science

A Study of the Perceptual Orientation of Community College Students and Their Attitudes Toward Science As They Relate to Science Achievement
Linda W. Crow and Martha K. Piper. 176

Developing an Instrument to Measure Scientific Attitudes
Carol Wareing. 178

Attitudes of Preservice Elementary School Teachers Toward Science Teaching: Antecedents and Response to Field Experience
Joseph C. Cotham 180

Session L-2. Teaching Strategies

The Effects of a Modified Mastery Learning Strategy on Achievement, Attitudes, and On-Task Behavior of High School Chemistry Students
F. Gerald Dillashaw and James R. Okey. 182

The Effects of Problem Solving Training in Science Upon Utilization of Problem Solving Skills in Science and Social Studies
Terry Shaw 184

Strategies Used by High School Students When Solving Genetics Problems
James Stewart. 185

Session L-3. Panel: Research and the Crisis in Science Education

Joseph Lipson; Robert Watson; Rita W. Peterson; and Kathleen M. Fisher 186

Session L-4. Cognitive Development

The Relationship Between Science Process Skill and Formal Thinking Abilities
Michael Padilla; James R. Okey; and F. Gerald Dillashaw. 188

The Effect of Science Teaching on the Fourth-Grade Child's Concept of Piagetian Physical Causality
Louis L. Gann and H. Seymour Fowler. 190

Session L-5. Research Seminar/Workshop: Assessing Pupil Engagement in Learning Activities

Continuation of Session K-5 175

CONCURRENT SESSION M

Session M-1. Committee Meetings

Session M-2. Test Instruments

The Development of an Inquiry Practical Examination for Upper Elementary Children
Edward L. Smith 192

The Development of a Test Instrument for Marine Knowledge of Adults in Northern New England
Wesley H. Hedlund and John W. Butzow. 194

An Analysis of Research Studies Utilizing "Home-Made" Achievement Instruments
Jean Hastings and James Stewart 196

Session M-3. Roundtable

Reasoning Patterns of College Level Science Students
George J. Pallrand; Michael Piburn; David Van Harlingen; Walter Lockwood; and William Martin 197

Session M-4. An Hour With the President-Elect

Session M-5. Roundtable: Science Education: Accomplishment and Needs
Robert E. Yager; John W. Renner; James J. Gallagher; and Ertle Thompson. 199

GENERAL SESSIONS

General Session I. The Place of Non-Quantitative Research in Science Education
Douglas Roberts. 41

General Session II. President's Address: The Power of Purpose
John W. Renner 71

General Session III. Naturalistic Inquiry and Conventional Inquiry: An Evaluation
Wayne W. Welch 130

General Session IV. Consideration of Types of Errors in Science Education Research
Arthur L. White. 200

Author Index 201

Session A-1

ENVIRONMENTAL PROBLEMS AND ISSUES IN MUSEUM RESEARCH

John J. Koran, Jr.
University of Florida and Florida State Museum
Gainesville, Florida 32611

Edward A. Munyer
Florida State Museum
Gainesville, Florida 32611

The basic unit of communication in a science museum is the individual artifact. Yet many artifacts require attention directing and controlling adjuncts in order to optimize their teaching effects. One way to ascertain which exhibits require alterations is to study visitor interaction with these exhibits using "naturalistic" study methods. Once visitor behavior relative to an exhibit is observed and recorded, experimental methods can be used to explore which adjunct to an exhibit is most effective for specific types of visitors.

The purpose of this paper is to: (1) describe the unique conditions encountered when doing research on science learning in informal museum settings, (2) describe a number of methodologies that have been tested and are being used to study science learning in the museum setting; (3) describe three types of science exhibits which are serving as the basis for this line of research and have interesting analogs in the school setting; and (4) briefly discuss the analogs to traditional science teaching that appear in the informal settings: "Static exhibit" - classroom, book, worksheet; "Walk-through exhibit" - field trip; and "Dynamic exhibit" - laboratory.

This paper should set the stage for the research studies to follow and the final discussion in this paper set.

Session A-1

STUDYING MODELING IN MUSEUMS

Lynn D. Shafer
John J. Koran, Jr.
University of Florida and Florida State Museum
Gainesville, Florida 32611

Jeff R. Lehman
Mary Lou Koran
University of Florida
Gainesville, Florida 32611

Edward A. Munyer
Florida State Museum
Gainesville, Florida 32611

Two studies were conducted in the museum setting utilizing "live" models to introduce and modify visitor behavior while visitors were observing a "hands-on" geologic change exhibit or a "walk-through" mesic hammock exhibit. Preliminary "observations" of the hands-on geologic change exhibit and how visitors related to it indicated that: (1) neither children nor adults touched the various minerals exhibited even though there was a "hands-on" sign present; (2) adults (over the age of 24) admonished children to keep their hands off the "hands-on" exhibits; (3) Some adults looked closely at the "hands-on" sign and mused aloud, "I wonder what that means?" (4) Most visitors of all ages moved right past this exhibit without stopping. Similarly, in the mesic hammock "walk-through" exhibit, observation indicated that: (1) Few people stopped at the head phone stations while walking through the mesic hammock; (2) More males than females stopped and looked around; (3) Visitors either ignored tape commentaries altogether, or listened to one tape and assumed all of the rest were the same.

In both studies, experimental intervention consisted of a "live" model strolling up to the "hands-on" exhibit or the walk-through exhibit and behaving in ways thought to be important in gathering audio, visual, and tactile information. Other experimenters unobstrusively observed the behavior of visitors who were observing the models and rated their performance.

Findings indicated that children showed a significantly greater tendency to touch specimens than adults (69% vs. 34%). Adult visitors in the modeling treatments consistently stopped, touched, and/or attended to objects or events which the model attended to while they did not in the non-modeling treatments. In the latter study, before modeling, no one stopped at listening stations in the mesic hammock. After modeling, a significant percent of the sample stopped at more than four stations. Similarly, the number of people not stopping at any of the stations was significantly reduced.

Session A-1

STUDYING MATHEMAGENIC BEHAVIOR IN MUSEUMS

Jeff R. Lehman
Mary Lou Koran
University of Florida
Gainesville, Florida 32611

Edward A. Munyer
Florida State Museum
Gainesville, Florida 32611

Lynn D. Shafer
John J. Koran Jr.
University of Florida and Florida State Musuem
Gainesville, Florida 32611

Twenty-nine seventh and eighth grade students were randomly assigned to two treatments and control as they entered the cave habitat "walk-through" exhibit at the Florida State Museum. All subjects were given set introduction materials saying in effect: (1) Treatment I- Enter the cave and study the habitat. When you exit at the other end, study the wall panel describing the many biologic relationships and organisms in the cave. After studying this panel you will be given a test to see how much you learned; (2) Treatment II- Study the wall panel describing the many biologic relationships and organisms in the cave before you enter it. Next, enter the cave and study the habitat. When you exit the cave you will be given a test to see how much you learned; and (3) Control- You will see a film on the Habitats of Florida that are represented in the museum. Later you will be given a test to determine how much you know about one specific habitat and then proceed with a tour of the museum.

A twenty-five item criterion test was designed to measure the acquisition of conceptual and factual knowledge and specific attentional factors relative to both the cave and the instructional panel. A KR-21 indicated that this instrument had a reliability coefficient of .72.

It was anticipated that the panel, used as an attention directing and controlling device prior to entering the cave (Treatment II) and upon exiting the cave (Treatment I), would function as a foward-shaping or backward review promoting adjunct; hence, both should be significantly more effective than the control. This was confirmed (df 2,26; f 8.09; $p \leq .01$). It was also expected that the forward-shaping panel would be more effective than the backward review panel in the tradition of advance organizers. Although the differences were in this direction, they were not significant ($p \leq .10$).

Session A-2

THE USE OF THE STATE-TRAIT ANXIETY INVENTORY IN THE MEASUREMENT OF ANXIETY ABOUT TEACHING SCIENCE IN PRESERVICE ELEMENTARY TEACHERS

Mary Westerback
C. W. Post Center
Greenvale, New York 11548

The researcher has found the State-Trait Anxiety Inventory (STAI) to be an easy to administer, reliable instrument useful in science education for the measurement of anxiety about teaching science in preservice elementary teachers. This assessment instrument was used to determine: (1) the effect of a sequence of content courses; (2) the relationship with attitude toward teaching science; (3) the effects of various teachers; (4) the effects of staffing patterns; (5) the relationships among various demographic variables; and (6) the "longitudinal" effects of subsequent academic experiences. In addition, it may be possible to identify "science anxious" students and design programs to reduce their anxiety.

Session A-2

A SCALOGRAM ANALYSIS OF TWO MEASURES OF CONCEPT GENERALIZABILITY

Walter E. Lowell
Kemal bin Abdullah
Boston University Medical Center
Boston, Massachusetts 02118

The purpose of this study was to develop and validate two hierarchically related measures of concept generalizability. The two concepts were Insect and Animal. The tests were organized in a novel format consisting of three degrees of stimulus complexity. The three degrees of complexity contained sets of pictures of each concept with each set of pictures displaying progressively fewer criterial attributes. The first set contained the most general. This organization assumed that children attaining the most general exemplars, demonstrating mastery of the concept, should be able to successfully identify exemplars in the two previous sets of pictures. It was therefore hypothesized that the tests should conform to Guttman Scalogram requirements, subjects unable to attain the first or second degree of complexity, should also fail the third degree of complexity. The sample consisted of 144 children ranging in age from 6 to 11 years. The results indicated that both measures conform to the Guttman Scalogram requirements and thus constitute valid scales. It was suggested that these tests would enable a more quantitative investigation of concept generalizability.

Session A-2

PREPARATION AND VALIDATION OF A VIDEOTAPED TEST OF CONSERVATION SUITABLE FOR GRADE SIX STUDENTS IN JAMAICA

Patricia A. Isaacs
University of the West Indies
Kingston 7, Jamaica

An attempt was made to produce an interesting standardized test of conservation by videotaping young people making preparations for a wedding. During the film, three questions were asked on each of the concepts of length and area, quantity and weight, internal and displaced volume, and the horizontal representation of waterlevels. The actors provided three alternative answers to each question and subjects indicated their choice by placing a tick in a lettered box on the answer sheet. Both reading and writing were thus effectively eliminated.

The test was administered to 586 students in their last few weeks of Primary (Elementary) schooling. Ten percent of the sample was retested four weeks later and the results produced a Pearson's r of 0.4699 ($p \leq .01$). Analysis showed that 102 out of 364 responses on the retest indicated conservation where it had not previously been displayed.

Analysis of the results of the three questions on each concept was done using a 2 X 2 matrix. It was intended that four of the concepts would have questions measuring different aspects of the concept. This was confirmed in the case of area, weight, and internal volume, but the results showed no distinction between displacement and deformation in length conservation.

Factor analysis was performed on the responses and associated biographical, sociological, and educational data. The conservation concepts appeared as Factor 2, while the horizontal representation of waterlevels was closely linked with the sex of the subject. A cut off point of .3 was accepted.

It was concluded that, while this type of test may act as a learning experience so that retesting may not be a valid technique to use, the conservation items may legitimately be grouped to form a test which does not overlap to any great extent with either mental ability or achievement tests. It is suggested that this type of test could be used to advantage when the thinking processes of individual students are not of principal concern. This type of test would be of particular use in the examination of groups of students whose limited reading and writing skills make other group tests impossible.

Session A-3

RESEARCH NEEDED TO BETTER UNDERSTAND DEVELOPMENTAL APPROACHES TO INSTRUCTION AND CURRICULUM DEVELOPMENT - A SYMPOSIUM

Michael R. Abraham
John W. Renner
University of Oklahoma
Norman, Oklahoma 73019

The intellectual development and learning (called "functioning" by Piaget) models of Piaget are interrelated and instruction and curriculum development and/or selection models can be inferred from them. A great deal of research and development have been based upon the Piagetian models which explains the value of those models in instruction and curriculum. The existing research, however, has also raised questions regarding the implementation of the instruction and curriculum models which are based upon the Piagetian models.

This symposium will concentrate upon four topics:

1. The Piagetian intellectual development and functioning models will be briefly explained.

2. The instruction and curriculum models inferred from the Piagetian models will be described.

3. The currently existing research relevant to one and two above will be reviewed.

4. The research needed to test the validity of the instruction and curriculum models inferred from the Piagetian models will be listed.

Session A-4

ANALYZING ARGUMENTS IN CLASSROOM DISCOURSE: CAN TEACHERS' QUESTIONS DISTORT SCIENTIFIC AUTHORITY?

Thomas L. Russell
Queen's University
Kingston, Ontario Canada K7L 3N6

Typically, teaching involves the asking of extended sequences of questions (Bellack et al., 1966; Hoetker and Ahlbrand, 1969) which enable a teacher to control the direction and duration of subject-matter discussion, while also maintaining a necessary degree of attention and order (Westbury, 1973). Science teachers have been urged to consider the form of their questions (as in the contrast between convergent and divergent questions), and in general there has been considerable attention to questions as means of instruction. At the same time, science teachers stand before their students as representatives of the discipline of science and of the community of active scientists. Although the nature of explanatory change in science is certainly not agreed upon, there is definite reluctance to base authority in science upon the pronouncements of particular individuals. Instead, reasons and evidence support the explanatory conclusions of the discipline. As an end of science instruction, we would have students view scientific authority in terms of reasons and evidence.

This paper reports an analysis of classroom discourse in which the use of questions by science teachers is assessed in terms of arguments to establish scientific knowledge claims. Questions are analyzed not for their form or frequency but for their function in the development of arguments which establish claims rationally. Seen in the context of rational argument, question sequences may be assessed as consistent with or distorting of the nature of scientific authority.

The study seeks to develop and demonstrate a plausible conceptual linkage between a science teacher's use of questions to develop student understanding and the associated provision for students to understand scientific authority. The method employed in the study involves development of an analytical scheme which is then applied to verbatim transcripts of classroom discourse (Munby, Orpwood, and Russell, 1980). Elements of rational arguments (Toulmin, 1958) and alternative attitudes to authority (Peters, 1966) are the philosophical considerations used to construct the analytical scheme. The link between use of questions and attitude toward authority is made by seeing questions in the context of the argument they are intended to develop.

Excerpts from three high school science lessons are analyzed in detail in the study. Initially, the selected excerpts simply seemed "disturbing," despite their adherence to familiar forms of teaching behavior. Analysis of questions within arguments reveals three different and intriguingly subtle ways in which the use of questions to develop a knowledge claim has failed to establish a rational argument. In each case, there is clear potential for distortion of student understanding of the nature of authority in science.

The study demonstrates that it is both possible and informative to analyze science classroom discourse in terms of suggested attitudes toward authority. The analytical scheme is straightforward and could be used by any science teacher who wished to review the use of questions in personal teaching behavior.

REFERENCES

Bellack, A. A., Kliebard, H. M., Hyman, R. T., and Smith, F. L. The Language of the Classroom. New York: Teachers College Press, 1966.

Hoetker, J., and Ahlbrand, W. P., Jr. "The Persistence of the Recitation." The American Education Research Journal, 1969, 6: 145-167.

Munby, H., Orpwood, G., and Russell, T. (eds.). Seeing Curriculum in a New Light: Essays From Science Education. Toronto: OISE Press, 1980.

Peters, R. S. Ethics and Education. London: George Allen and Unwin, 1966.

Toulmin, S. E. The Uses of Argument. Cambridge: The University Press, 1958.

Westbury, I. "Conventional Classrooms, "Open" Classrooms, and the Technology of Teaching." Journal of Curriculum Studies, 1973, 5: 99-121.

Session A-4

STUDENT BEHAVIORS IN DESEGREGATED JUNIOR HIGH SCHOOL SCIENCE CLASSROOMS

Bessie A. Stanbaack
Syracuse University
Syracuse, New York 13210

Recent literature has indicated that minority students are not enrolling in elective secondary science courses. Other literature has emphasized the importance of positive junior high school science experiences, especially for minority students. Before changes can be made that might lead to increased minority student enrollment in elective science courses, there is a need for classroom behavior studies to determine the behaviors and interpersonal interactions that take place in junior high school science classrooms that contain a high proportion of minority students.

This investigation focused on the use of class time by students in junior high school science classrooms. Classrooms that were desegregated and activity-oriented were observed. The purposes of the study were to develop an instrument to assess classroom behaviors and interactions of students, and to use this instrument in obtaining information about classroom behaviors that might affect minority student outcomes in science

The sample for this study was comprised of students from a desegregated urban school district in which an activity-oriented approach to instruction was being used. Fifty-two subjects (students on whom observers focused), several hundred target students (students with whom subjects might interact), and six teachers at four differenct junior high schools participated in the study.

An on-site time sampling procedure was used to collect data on the student behaviors. These behaviors were broadly classified into attending and non-attending behaviors with each category being subdivided. Trained observers used the developed instrument for observing and recording the student behaviors. Information about the interactions of each subject student with target students and teachers was recorded and used in the analysis of the data.

The results from the analysis of the data obtained from the observations indicated the following:

1. The developed instrument can be used successfully to observe student behaviors and interactions in individualized activity-oriented science classrooms.
2. Even though the students were free to interact, very few cross-race interactions took place.
3. The frequency of attending behaviors was greater than the frequency of non-attending behaviors for male students of both races.
4. No significant differences existed between black male students and white male students in classroom behavior patterns (i.e., the frequency of attending and non-attending behaviors).

5. The average final grade for black male students was lower than the average final grade for white male students.

Some of the conclusions from this study were:

1. Desegregated schools may have segregated classrooms.
2. Although black and white male students exhibited similar classroom behaviors, the average final grade was higher for whites than for blacks. This may be a source of discouragement and negative attitude for blacks.
3. The instrument developed for this study has proven to be useful and reliable and is suitable for use by other researchers who are seeking to understand classroom process variables.

Session A-4

THE EFFECTS OF BEHAVIOR MODEL ANALYSIS ON TEACHERS' BEHAVIORS DURING SCIENCE ACTIVITY LESSONS

P. Ann Miller
University of Georgia
Decatur, Georgia 30033

The purpose of this study was to investigate the effects of teacher training strategy on science activity lesson teaching behaviors of preservice teachers. The relationship between teaching behaviors and achievement of pupils was also investigated. The following research questions provided the primary focus for the study:

1. What effect do variations in model analysis training strategies have on the teaching behaviors of preservice teachers?
2. What is the relationship between the preservice teachers' behaviors and pupil achievement?

Preservice teachers enrolled in elementary, middle school, and secondary science instructional methods courses were involved in this study. The 43 preservice teachers were distributed evenly across the three training levels. All experimental and control teachers were introduced to the activity lesson instructional behaviors. The two experimental groups of teachers then viewed and analyzed video taped model activity lessons. The Science Laboratory Analysis System (SLAS), a sign observation system consisting of 28 behaviors, was used for the lesson analysis. One group of experimental teachers viewed only positive models while the other experimental group viewed both positive and negative models. The control group received no further instruction behond the initial introduction to the activity lesson behaviors.

Behaviors of each preservice teacher were assessed on two science activity lessons, one taught to peers in a micro teaching situation and one taught to a class of public school pupils. Two observers used the SLAS to assess both lessons of all teachers.

Pupil achievement was measured with pre- and post-tests based on the lesson objectives. A standardized gain score was then calculated for each public school class and the class was used as the unit of statistical analysis.

The model analysis training strategies produced significant differences in the preservice teachers' instructional behaviors. Both experimental groups used significantly more of the 28 behaviors coded with SLAS than did the control group ($p \leq 0.001$). Differences in behaviors between the two experimental groups were not significant ($p > .10$). A significant positive correlation, $r=0.4$ ($p \leq 0.003$), was found between teaching behaviors and pupil achievement.

The results of this study indicated there are particular science teaching behaviors that are correlated with achievement in science. Also the degree of incorporation of these behaviors into a lesson can be influenced by engaging teachers in systematic analysis of model lessons.

Since the ultimate goal of teacher training is to influence pupil learning in the public school classroom, the experimental treatments investigated in this study should be considered as viable training curriculum for our science teaching methods courses.

Session B-1

PATTERNS OF REASONING: CONTROLLING VARIABLES

William Capie
Roger Newton
University of Georgia
Athens, Georgia 30602

Kenneth G. Tobin
Mt. Lawley College
Perth, Australia

Cognitive development is an important area for educators and psychologists. Controlling variables is one of five reasoning modes having particular relevance to science instruction. Although numerous studies have reported the development of reasoning skills, few have dealt with controlling variables or assessed the generalizability of reasoning patterns over variations in context and in the reasoning modes, themselves.

Purpose

Three objectives for this study were to determine if developmental patterns in the ability to control variables:

1. could be identified in a large, diverse sample;
2. were similar regardless of problem context; and
3. were similar for subjects of similar developmental levels regardless of educational level.

Proceedures

Data from 2282 subjects in grades 6-13 were collected using the Test of Logical Thinking (TOLT) (Tobin and Capie, in press). The test characteristics are well documented (Capie and Tobin, 1980). Subjects are presented two problems representing each of five reasoning modes including controlling variables. TOLT Form A involves two problems dealing with pendula; Form B involves two problems dealing with rolling cylinders down inclined planes. One question requires the subject to vary the weight; the other requires that it be held constant. Subjects choose one of five sets of apparatus to use in an investigation and choose a justification for their choice from among five alternatives. The correct answer is the correct choice plus the correct justification.

The most common combinations of responses and reasons were selected for additional study. Subjects were sorted by TOLT scores, 0-10, to represent increasing developmental levels. Frequences were displayed graphically to facilitate interpretation and comparison of analogous items.

Form A subjects were categorized by educational level and by developmental level with levels of interest being transitional (TOLT scores 2-3) and early formal (TOLT scores 4-5). A Chi-square analysis was used to determine if the response patterns for each of the two controlling variables tasks differed among subjects of similar developmental levels but differing educational levels.

Results

Four common response patterns occurred for each item:

1. Correct response and correct reason:
2. Testing all possibilities without controlling variables;

3. Testing extreme examples (such as longest and shortest) without controlling variables; and

4. Testing all possibilities despite recognizing that a variable should be held constant.

In all four problems, substantial numbers of concrete thinkers (Low TOLT scorers) chose to test all possibilities or the two extremes. The proportion of correct responses increased consistently at all developmental levels except for slight variations around TOLT scores 3-5.

Non-significant Chi-square values showed that response patterns for transitional and early formal subjects were similar regardless of educational level.

Discussion

The study revealed three common approaches by individuals confronted with situations where variables should be controlled. There are few clues in this investigation as to whether focusing on the two extreme examples or all possible examples is the first step in the emergence of controlling variables.

The similarity in patterns across students of different educational levels suggests that inadequate reasoning patterns are similar among students of all educational levels. More open or interactive testing situations may have enabled older students to perform differently.

REFERENCES

Tobin, K. G. and Capie, W. "The Development and Validation of a Group Test of Logical Thinking." Journal of Educational and Psychological Measurement. (in press).

Capie, W. and Tobin, K. G. "Establishing Alternate Measures of Logical Thinking for use in Group Settings." Paper presented at the annual meeting of the American Psychological Association, Montreal, September 1980.

Session B-1

PATTERNS OF FORMAL REASONING: PROBABILISTIC REASONING

Kenneth G. Tobin
Mt. Lawley College
Perth, Australia

William Capie
Roger Newton
University of Georgia
Athens, Georgia 30602

The study of formal reasoning ability has become increasingly important as educators and psychologists endeavor to understand learning in adolescence and adulthood. This study examined developmental patterns in one mode of formal reasoning, probabilistic reasoning, for a large diverse sample of subjects.

Purpose

The following objectives provided a focus for the study:

1. to determine if developmental patterns of probabilistic reasoning could be confirmed using a large, diverse sample of subjects.
2. to determine if developmental patterns of probabilistic reasoning were similar despite variations in the complexity of the reasoning required to solve a problem.
3. to determine if variations in problem context led to variations in response patterns.
4. to determine if developmental patterns of probabilistic reasoning were similar for subjects of similar formal reasoning ability regardless of educational level.

Proceedures

Data from 2282 subjects in grades 6-13 were collected using the Test of Logical Thinking (TOLT) (Tobin and Capie, 1980). Form A was used to assess 1627 subjects and form B was used to assess 655 subjects. The characteristics of each test form have been documented elsewhere (Capie and Tobin, 1980). Psychometric characteristics, item format, and the existence of parallel forms made the TOLT particularly well suited to this investigation. In each test form, the first probability item was less complex than the second item.

Subjects were ranked on the basis of their total performance on TOLT. Response patterns were separately analyzed at each of the eleven levels of formal reasoning ability represented by the scores on the TOLT (0-10). Similar analyses were conducted for samples defined on the basis of educational level: college students; high school students; and middle school students.

Results

For each of the four items, the proportion of students obtaining a correct response was linearly related to formal reasoning ability, and measured on the TOLT. Two common approaches were identified for individuals attempting to use probabilistic reasoning to solve problems. The two problems that tended to occur were:

1. subjects considered the entire set of objects, but did not consider the effects of multiple elements from the favorable outcome set; or

2. subjects only considered selection from the favorable outcome set and ignored the presence of other sets of objects.

Similar response patterns were evident in items requiring simple or complex reasoning.

Changes in the context from Form A to Form B produced few noticeable changes in response selection. Reasoning patterns tended to be independent of the problem setting.

Statistical analysises of six response combinations at three educational levels indicated that similar response patterns were provided by subjects at each educational level.

Implications for instruction, research, and the methodology used to assess probabilistic reasoning are fully discussed in the paper.

REFERENCES

Capie, W. and Tobin, K. "The Development of Alternative Forms of Logical Thinking." Paper presented at the annual meeting of the American Psychological Association, Montreal, September, 1980.

Tobin, K. and Capie, W. "The Development and Validation of a group test of Logical Thinking." Paper presented at the annual meeting of the American Educational Research Association, Boston, April 1980.

Session B-1

PATTERNS OF REASONING: PROPORTIONAL REASONING

Roger Newton
William Capie
University of Georgia
Athens, Georgia 30602

Kenneth G. Tobin
Mt. Lawley College
Perth, Australia

Cognitive development has been recognized as an important mediator of achievement in science and mathematics. Proportional reasoning has been the most intensively investigated among the formal reasoning modes. This study addresses three major questions regarding the development of proportional reasoning.

Purpose

The objectives of this study were to determine the developmental patterns in proportional reasoning and to determine if these patterns are similar regardless of educational level and regardless of problem context.

Procedures

Data from 2282 subjects in grades 6-13 were collected using the Test of Logical Thinking (TOLT) (Tobin and Capie, in press; Capie and Tobin, 1980). In each TOLT Form subjects are presented two problems requiring proportional reasoning. The two problems differ both quantitatively and qualitatively. The subjects are required to select the best answer from five choices and to identify their reason from five alternatives. Twenty-five combinations, then, are possible. The four most common combinations were selected for additional study.

The data were examined for subjects who had been categorized in three ways: (1) by TOLT scores, 0-10, (2) by educational level; and (3) by developmental stages within each educational level.

Results

The four most common responses, in order of frequency, were:

1. correct answer and correct reason;
2. focus on a single difference (additive thinking);
3. there is no way to predict;
4. correct reason but with an arithmetically incorrect answer (e.g., 9 instead of 8 2/3).

In general, the observed patterns of reasoning are similar regardless of developmental level, educational level, or problem context.

Discussion

Large portions of our students did not solve problems requiring proportional reasoning. The incorrect response combinations suggest emerging developmental patterns. The mode of reasoning just prior to the development of a proportionality scheme is clearly additive. Furthermore, these patterns are similar across the two problem contexts studied.

One interesting result was that the level of arithmetic computation seems to be an important variable in assessing proportional reasoning ability. The data provide only mixed support for the notion of continuous development of proportional reasoning.

Conclusions and Implications

The physical sciences, expecially, and biological science, to a lesser degree, involve great use of proportional reasoning. Science teachers and educators should not assume that students enter science instruction equipped with the cognitive ability to handle concepts in these areas. Indeed, they should be aware of the developmental patterns that exist and use instructional strategies that promote proportional reasoning.

REFERENCES

Tobin, K. G., and Capie, W. "The Development and Validation of a Group Test of Logical Thinking." Journal of Educational and Psychological Measurement. (in press)

Capie, W. and Tobin, K. G. "Establishing Alternative Measures of Logical Thinking for Use in Group Settings." Paper presented at the annual meeting of the American Psychological Association, Montreal, September, 1980.

Session B-1

PATTERNS OF REASONING: CORRELATIONAL THINKING

Danny L. McKenzie
Michael Padilla
University of Georgia
Athens, Georgia 30602

Much recent interest in cognitive development undoubtedly reflects a simple need to understand the evolving thought processes of youngsters through adolescence. Other interest stems from the knowledge that cognitive development has great potential for helping researchers to understand the effectiveness of particular teaching and learning strategies. Five reasoning modes are identified as having particular relevance to science instruction: controlling variables, proportional reasoning, probabilistic reasoning, combinatorial reasoning, and correlational reasoning. If allowance for variation in reasoning ability is to be made in instruction, then efforts must be made to understand these various reasoning modes and their development.

Few studies have dealt specifically with correlational reasoning or assessed the generalizability of reasoning patterns over variations in context and over variations in the reasoning modes, themselves. In the one exception it was found that four basic levels of responses to the correlations problems were prevalent, each level roughly corresponding to the Piagetian levels IIa, IIb, IIIa, and IIIb. The lack of other studies supporting these results or proposing alternate models has lead to this study.

Purpose

The three main objectives for this study were:

1. to determine if developmental patterns in correlational reasoning could be identified among a large and diverse sample;
2. to determine if developmental patterns in correlational reasoning were similar regardless of problem context; and
3. to determine if developmental patterns in correlational reasoning were similar for subjects of similar developmental levels regardless of educational level.

Proceedure

Data from 2282 subjects in grades 6-13 were collected using two parallel forms of Test of Logical Thinking (TOLT). Two of the ten items on each form measured correlational thinking abilities and it is these items that were analyzed for this study. Each item consisted of two questions. One asked the student to decide whether a correlation existed between two attributes of an object, (e.g., between the size of mice and the color of their tail). The second asked the student to choose a justification, from among five, that explained their answer. The most common responses were chosen for further study.

Results

Four common response patterns (three incorrect and one correct) occurred for each item. They were:

A. No relation among different variables was considered in the justification.

B. Only two values of the attributes were considered in the justification.

C. All four values of the attributes were considered to make two comparisons.

D. A quantitative comparison using all four attributes was used to correctly solve the problem.

When these response patterns were analyzed by developmental level (concrete, transitional, and formal) and by educational level (middle school, high school, and college) certain patterns emerged. The predominant response of concrete thinkers was A, which was thought to be early concrete in nature. For transitional students, a shift in responses toward more adequate, but still incorrect responses (B and C), and toward the correct response is evident. Formal students primarily gave correct responses. While college students performed better than high school students and high school better than middle school students, response patterns were more predictable and stable across developmental level than educational level. Thus concrete students tended to respond in similar ways regardless of educational level. A Chi-square analysis of data within each developmental level was not significant for different educational levels, thus confirming the above analysis.

Discussion

Three common error patterns were identified in this study which reflect similar patterns described by Adi, et al. (1978). While corraboration of the Adi, et al. (1978) findings is limited because TOLT items did not use an open response pattern, trends in the data support a similar developmental pattern. The data are not clear on how teachers might encourage those who do not use correlational reasoning properly. However, recognizing the level of reasoning a student is using and leading him toward adapting progressively more complicated problem solving strategies has potential for future research.

REFERENCE

Adi, H.; Karplus, R.; Lawson, A.; and Pulas, S. "Intellectual Development Beyond Elementary School VI: Correlational Reasoning." School Science and Mathematics, 1978 78: 675-683.

Session B-2

THE MAJOR QUESTIONS ADDRESSED BY THE EXTANT SCIENCE EDUCATION RESEARCH: A MAP FOR META-ANALYSIS

Ronald D. Anderson
Stuart R. Kahl
Mary Lee Smith
Gene V Glass
University of Colorado
Boulder, Colorado 80309

Russell H. Yeany
University of Georgia
Athens, Georgia 30602

As the first phase of a large scale meta-analysis of the field of science education, a process was initiated to identify the major research questions pursued in the extant science education research literature and organize them in a manner that would provide a conceptual framework for meta-analysis. This analysis of the major research questions and the variables involved was conducted by a combination of (1) empirical analysis of the extant research and (2) expert judgment as to the importance of particular questions.

The first step was to review a sample of 300 research articles selected across time and type of publication and record the research questions addressed. Full descriptions of the broad areas were then developed and submitted to twenty leading science educators for review as to their importance and the adequacy of their literature for purposes of meta-analysis. Extensive literature searches also were conducted on a sampling basis to determine the size of the literature for each generic question.

A two-day conference of five leading science educators from across the country then was convened to confer with the project staff and produce a final classification of research questions for meta-analysis, as well as to identify important variables to include when integrating the research for each question.

After eliminating one of the thirteen questions due to insufficient empirical research, the other twelve were recombined into six broader categories. This set of categories is presented as a framework for a meta-analysis of the extant science education research.

Session B-2

A META-ANALYSIS OF THE RELATIONSHIP BETWEEN SCIENCE ACHIEVEMENT AND SCIENCE ATTITUDE: KINDERGARTEN THROUGH COLLEGE

Victor L. Willson
Texas A&M University
College Station, Texas 77843

The relationship between science attitude and science achievement has been examined for almost fifty years. Reviews of science education research have summarized such research and generally concluded that the relationship is positive and fairly large in magnitude. In many cases these conclusions are based on only a few studies, even though well over one hundred studies have examined the relationship. There has been no comprehensive, thorough review of the topic utilizing new methodological techniques for integrating research findings.

Meta-analysis is an integrative technique for summarizing results of research studies in a statistical manner. It was recently applied to the relationship between science attitude and science achievement for secondary level students. In this paper the technique is utilized for research which has been performed over the last fifty years on children from grades kindergarten through undergraduate college level. Branching library research and ERIC Resources were used to find over one hundred separate studies. These studies include dissertations, ERIC documents, journal articles, and government reports. Thirteen independent variables were coded for each study to represent the various conditions that distinguish one study from another. These include population characteristics, design characteristics, type of attitude measure, and type of achievement measure. Descriptive statistics, multiple regression, and analysis of variance were used to examine the correlation coefficients extracted from each study.

Results are incomplete at the time of this abstract, but preliminary data indicate a strong positive relationship for elementary level children, small positive relationship for secondary level children, with no results yet available for college students. Selection and restriction of range are discussed as influences on the variation in correlation found in the study.

Session B-3

BUILDING A BASE OF COMMUNITY SUPPORT FOR SCIENCE EDUCATION

William C. Ritz
California State University
Long Beach
Long Beach, California 90840

Kenneth W. Dowling
Wisconsin Department
of Public Instruction
Madison, Wisconsin 53702

Herbert D. Thier
University of California
at Berkeley
Berkeley, California 94720

Charles W. Wallace
National Science Foundation
Washington, D.C. 20550

Floyd E. Mattheis
East Carolina University
Greenville, North Carolina 27834

The current low ebb of science in the schools of our nation is well known to the science education community. We worry about it, we bemoan the fact that the public no longer supports science education as enthusiastically as it once did, and we wish that things would get moving once again. However, Walt Disney's First Law ("Wishing will make it so.") seems not to be working for us! If science is to be restored to its rightful position in the school curriculum, educators everywhere will have to work at developing a strong base of community support. It won't happen unless we help to make it happen!

The panel addresses this issue. Following a brief introduction outlining the current plight of science education in the United States, the panel will turn its attention to specific ways of building that base of support. Since each of the panelists is already involved in some form of community outreach on behalf of science, a major portion of each person's presentation will involve describing how these various forms of outreach operate. Among the types of outreach to be discussed are: (1) a collaboration between a public university and a county education office; (2) a university-based research center in science education; (3) a Cooperative for Science Teaching, developed through a university Department of Science Education; and (4) the outreach programs of a State Department of Public Instruction.

Session B-4

RELATIONSHIPS BETWEEN ABSTRACT REASONING, INSTRUCTION, AND ACHIEVEMENT ON A PHYSIOLOGY UNIT STUDIED IN TENTH GRADE BIOLOGY

Eugene L. Chiappetta
University of Houston
Houston, Texas 77004

Biology course subject matter presents a unique problem to instructional planners. The conceptual difficulty of biological concepts varies considerably; some appear to be rather concrete while others appear to be rather abstract. Concepts relating to human physiology taught in high school biology appear to exist somewhere in between these two extremes. One important question related to teaching biology at this level is what type of abstract reasoning ability is most closely related to learning concepts associated with human digestion.

The independent variables of the study were three types of abstract reasoning constructs (logical thinking, figural reasoning, and verbal reasoning) and an instructional variable (a modified mastery learning strategy). The dependent variable was achievement of concepts related to human digestion.

One hundred and forty-three subjects enrolled in tenth-grade biology participated in the study. About one-half of the students were assigned to traditional instruction and one-half to a modified mastery learning instructional format. Four biology teachers were randomly assigned to one of four treatment groups. The treatments lasted six weeks and were centered on human physiology.

The findings show that the four predictor variables accounted for a significant ($p \leq .001$) portion of the variance in achievement. Figural reasoning appears to have the strongest relationship with human physiology concepts taught at the tenth grade level. The modified mastery learning strategy instruction appears to have very little effect on improving achievement.

Session B-4

THE EFFECT OF INSTRUCTION USING STUDENTS' PRIOR KNOWLEDGE ON CONCEPTUAL CHANGE

M. G. Hewson
University of the Witwatersand
Johannesburg, 2001 South Africa

One of the factors affecting students' learning in science is their existing knowledge prior to instruction. The students' prior knowledge provided an indication of the preconceptions and alternative conceptions as well as concepts not yet possessed by the students. This study is concerned primarily with the students' pre- and alternative conceptions and with an instructional strategy to effect conceptual change from these conceptions to scientific concepts. The conceptual change theories used here suggest conditions under which alternative conceptions can be replaced by scientific concepts, preconceptions can be differentiated and elaborated, and new concepts can be integrated with the existing concepts.

The instructional strategy and materials were developed for a particular student population, namely, black high school students in South Africa, using their previously identified prior knowledge (preconceptions and alternative conceptions) and incorporating the principles for conceptual change. The concepts involved were mass, volume, density, relative density, and the particulate nature of matter.

An experimental group of students was taught these concepts using the special instructional strategy and materials. A control group was taught the same concepts using a traditional strategy and materials. A pre- and post-test was used to assess the conceptual change that occurred in the experimental and control groups. The results showed a significantly larger improvement in acquisition of scientific concepts as a result of the instructional strategy and materials which explicitly dealt with student pre- and alternative conceptions.

Session B-5

INVESTIGATIONS OF MALE-FEMALE DIFFERENCES IN SCIENCE PERFORMANCE: LEARNER CHARACTERISTICS OR LEARNER EXPERIENCES?

Elizabeth K. Stage
Marcia C. Linn
Steven Pulos
University of California, Berkeley
Berkeley, California 94720

Beverly Birnes
The State University of New York
at Stony Brook
Stony Brook, New York 11794

Wayne W. Welch
University of Minnesota
Minneapolis, Minnesota 55455

Recently researchers examining male-female differences in science performance have considered learner characteristics and learning experiences. Science performance measures considered in this symposium include formal reasoning tasks, program persistence measures, and achievement items. The learner characteristics that have been examined by these researchers include cognitive and affective factors such as fluid ability and crystallized ability, field dependence/independence (FDI), processing capacity, spatial ability, confidence, and attitudes. The learning experiences that have been investigated by these researchers include instructional experiences, such as (1) number and type of courses taken in math and science; (2) training experiences to minimize male-female differences; and (3) environmental experiences stemming from attitudes and expectations of teachers and peers.

The symposium participants have studied science performance from early adolescence to early adulthood. Three participants are educational psychologists at a science education research and development center who have collaborated on a series of mathematical and scientific reasoning in early adolescence. One of these researchers will emphasize affective factors influencing performances that explain male-female differences. Another will report on the cognitive correlates associated with performance; the third will present results of a training study aimed at reducing male-female differences on a specific task.

Another participant in the symposium is also an educational psychologist who will report on analyses of male-female differences on the math and science achievement items from the NAEP data. These analyses have concentrated on mathematics and science course taking, and attitudes and study habits that are related to NAEP performance. The final presenter is a psychologist involved in women's studies, reporting on a study of persistence in undergraduate science programs. Differences in predictor variables for males' and females' success will be highlighted.

Following brief presentations of these recent research studies, the symposium participants will discuss the relative importance of learner characteristics and learning experiences in the evolution of and elimination of male-female differences in science performance.

Session C-1

THE DIFFERENCES AMONG SCIENCE AND HUMANITIES MALES AND FEMALES

Dale R. Baker
Rutgers University
New Brunswick, New Jersey 08903

The low number of women in science has become a major concern of science educators in the last few years. Various programs have been established to increase their numbers by providing skills, information, and role models. This concern has led to the present study.

The focus of this study is the characteristics of women in science; the purpose is to identify factors which would discriminate among males and females in the humanities, biological, and physical sciences. The areas of spatial ability, attitude toward science, and rate of maturation were chosen as possible discriminating variables because previous research on sex differences indicate that males are better at spatial tasks than females (Maccoby and Jacklin, 1974) and that spatial ability is a factor of success in science (Talley, 1973; Siemankowski and McKnight, 1971). Boys also have a more favorable attitude toward science than girls (Koelsche and Newberry, 1971; Lowery, 1967). Rate of maturation according to Bem (1975) is a discriminating characteristic of individuals linked to spatial ability in that early maturing males and females have poorer spatial ability than late maturing males and females.

Eighty-six male and female undergraduate humanities and science majors were given two Educational Testing Service spatial tests. Additional information concerning major, science hobbies, number of previous science course, and a short essay on their feelings about pursuing a career in science was collected.

Rate of maturation was measured by retrospective report for the onset of menarche for females and the age of adolescent growth spurt for males.

The data were subjected to a discriminant analysis with sex, major, and sex-major as separate dependent variables. There were no variables which were able to predict sex. Attitude, number of science courses, and spatial ability were the discriminating variables which distinguished science from non-science majors. The last analysis using sex and major indicates that attitude and spatial ability were the discriminating variables between science and humanities majors. Group centroids show that within groups it was not possible to distinguish between sexes or between biological and physical science majors.

Correlations indicate that there was no relationship between rate of maturation and the other variables so that Bem's (1975) hypothesis that women have poorer spatial ability than men because they mature earlier than males was disconfirmed. Spatial ability correlated significantly ($p \leq .001$) with major (0.30), courses (0.40), and attitude (0.40). Within the science group for males, attitude correlated with spacial ability but for females the only correlation with attitude was the number of science courses previously taken.

It appears that the factors which influence a choice of career in science regardless of sex are spatial ability and a positive attitude toward science. The attitudinal factor is more important than the cognitive factor

for women in that a woman with good spatial ability but a negative attitude toward science will probably not enter the sciences. Once women are in the sciences it is not possible to distinguish them from men on the basis of spatial ability.

REFERENCES

Bem, S. L. "Sex Role Adaptability: One Consequence of Psychological Androgeny." Journal of Personality and Social Psychology, 1975, 31 (4): 634-643.

Koelsche, L. and Newberry, S. L. "A Study of the Relationship Between Certain Variables and the Science Interests of Children." Journal of Research in Science Teaching, 1971, 8: 237-241.

Lowery, E. F. "An Experimental Investigation Into Attitudes of Fifth Grade Students Toward Science." School Science and Mathematics, 1967, 67: 569-579.

Maccoby, E. E. and Jacklin, C. The Psychology of Sex Differences. Standford: Standford University Press, 1974

Siemankowski, F. T. and McKnight, F. "Spatial Cognition: Success Prognostication in College Science Courses." Journal of College Science Teaching, 1971, 1: 56-59.

Talley, L. "The Use of Three Dimensional Visualization as a Moderator in Higher Cognitive Learning Concepts in College Level Chemistry." Journal of Research in Science Teaching, 1973, 10: 263-296.

Session C-1

COLLEGE PHYSICS ACHIEVEMENT: DO FEMALES AND MALES DIFFER?

David Van Harlingen
Rutgers University
New Brunswick, New Jersey 08903

In the last decade, continued concern has been expressed over the small percentage of women pursuing careers in the physical sciences. This study sought to determine whether women, in general, enter an introductory physics course with the same cognitive skills as men and whether differences exist between the sexes on pretests or in course performance.

Subjects were 500 students taking an introductory calculus based physics course at an Eastern state university. Most were sophomores with 40% of the students being female. Students completed a pretest battery assessing skills in mathematics, logic, and spatial operations.

Males outscored females on one part of mathematics (trigonometry) and on spatial rotation. Females were superior in verbal skills. There were no differences on other measures.

Course achievement was defined as a student's score on eighty multiple choice problems given in three examinations. Males outscored females by 3.5 questions ($p \leq .001$). When pretest differences were controlled the difference was reduced to 2.5 questions ($p \leq .01$).

Separate regression analyses indicate that achievement for males is predicted by a variety of skills ($R^2=.33$) while for women, achievement in physics is a function only of mathematics skills ($R^2 =.26$) among the skills assessed.

These results suggest that the utilization of a multitude of skills may produce better course results and that supportive programs are best directed toward the coherent use of many skills in a problem solving context.

Session C-1

SEX DIFFERENCES IN COLLEGE LEVEL GENERAL BIOLOGY

Veronica Mondrinos
Rutgers University
New Brunswick, New Jersey 08903

It is well known that women are underrepresented on most levels and in most fields of science. By the mid 1970's the proportion of women in most scientific fields had just climbed back to the levels of the 1920's (Briscoe, 1979). Explanations for this situation are varied and include early educational biases that steer women away from science and math courses and the absence of role models in these courses (Joyce and Hall, 1977). The fact that girls face a defininte cultural bias which acts to deemphasize science has been frequently documented in the last decade (Buttron and Brown, 1980). It is generally accepted that it isn't "girlish" to like science and perform well in it (Buttron and Brown, 1980). Research dealing with the high school level shows that girls generally score as well as the boys and represent only a slightly smaller proportion in number than the boys in most science courses (Zinberg, 1977). This however does not seem to be the case on the college level where the females represent a proportionately smaller number in most science courses. Not only are they low in numbers, they also attain lower scores and leave the sciences early in their academic careers.

General Biology on the college level seemed to be one course that would be worthwhile to study since many of the previously mentioned findings appear to be disconfirmed.

The study took place at a large eastern university and examined the progress of women in two introductory biology courses. The total number of students tested was 668 (Female=341; Male=327). They were given knowledge pretests (SAT Biology), the Propositional Logic Test (PLT) and an attitude test during the first few weeks of the semester. Their SAT Math and Verbal scores were obtained prior to the post testing which consisted of a knowledge post test (Advanced Placement Test in Biology) and the same attitude test. A questionnaire was also used to determine the number of years of high school science taken and to obtain a science interest and knowledge score.

Pretest results showed that the females (mean=34.38) in both courses obtained substantially lower scores than the males (mean=38.73). The means for the SAT Verbal were the same for both groups, but the SAT Math scores were different. The males had a mean score of 40 points higher than the females. The PLT scores and the attitude scores were the same for both groups. In the traditional biology class the girls represented 54 percent of the class while in the more advanced course they represented only 30 percent of the class. The post test results showed that the females (mean=43.5) had attained as much knowledge or more knowledge than the males (mean=44.46).

The results indicate that although the females enter the course with poorer backgrounds (SAT Biology, SAT math) they catch up during the course of the year, and in some cases surpass the males. It could therefore be argued that the females have the competencies necessary for success in science but that they were not tapped in their previous exposures to science courses.

REFERENCES

Briscoe, Anne. "Sex and Science." Science, 1979, 205: 670-671.

Buttron, L. and Brown, R. "Women in Science." School Science and Mathematics, 1980, 30: 206-209.

Joyce, N. and Hall, P. "Women Researches Analyze Education and Job Barriers." Science, 1977, 198: 917-918.

Zinberg, E. "Still Many Barriers to Women in Science." Science News, 1977, 112: 279.

Session C-2

PERFORMANCE ASSESSMENT OF ELEMENTARY SCHOOL SCIENCE TEACHERS

Dale G. Merkle
Shippensburg State College
Shippensburg, Pennsylvania 17257

The major purpose of the project was to assess the competencies which have been developed for the Teaching of Elementary Science course by observing recent graduates of the college as they teach science and by interviewing them concerning their science teaching.

An instrument was developed for rating teacher behavior in each competency area. Observations were made by college and school district reprsentatives. The ratings were coded to allow analysis. The correlation between ratings done by different observers ranged from .40 (moderate) to .78 (substantial).

Two competencies rated well below the others. They were: (#9) - the utilizing of secondary sources in teaching and (#1) - the ability to select and plan activities of instruction that reflect the needs of students, the developmental level of the students, the developmental level of the concept or conceptual scheme, and the materials and equipment available. Examination of methods to enhance delivery in these performance areas is to be undertaken in this academic year.

The single most disturbing factor in completing the project was the lack of cooperation from former students. Over fifty percent of the graduates contacted refused to cooperate in the study. Many reasons were given for not participating. The primary reasons seemed to be a lack of confidence in their science program or no science program at all, and a fear of being observed, particularly by persons from their school districts.

All competencies received a rating above the mean (rating could range from 0-5). Where science is taught, it is generally taught well. It was apparent from data collected in the interviews that the teaching of science in elementary schools is perceived by many teachers, however, to be a secondary subject goal at best.

Session C-2

THE PREDICTORS OF SCIENCE TEACHING PERFORMANCE IN ELEMENTARY SCHOOL TEACHERS

Mildred R. Green
Fordham University
New York, New York 10023

Researchers in science teaching have demonstrated that student-oriented teaching methods have a positive effect on learners. In addition, research in other areas of instruction indicate that the amount of classroom time that teachers allocate to a given content area is related to student achievement. Clearly, the quality of science education hinges on these two areas of teaching performance. The present study investigates professional and motivational factors in teachers that are related to their choice of teaching method and their persistence in teaching science in the elementary school.

Session C-2

A FACTOR ANALYTIC STUDY OF SECONDARY SCIENCE TEACHER COMPETENCIES WITHIN WHICH GROWTH IS PERCEIVED AS IMPORTANT BY SCIENCE TEACHERS, SUPERVISORS, AND TEACHER EDUCATORS

H. Craig Sipe
Bruce Tulloch
The State University of
New York at Albany
Albany, New York 12222

The purpose of this investigation was to determine which fundamental skill repertoires were operant withing a national sample of science educators as they assessed the relative importance of growth within a selected set of science teacher competencies for ultimate science teacher effectiveness. It was the objective of this study to identify, through factor analysis, the underlying constructs which would add clarity and parsimony to the interrelationships existing among the sample's attributions of relative importance of growth in those competencies to effective science teaching. The identification of those factors operant within the perceptual response data obtained would facilitate both the efforts of the preservice or inservice teacher educator and the science teacher effectiveness researcher. A secondary objective of this study was to determine for which factors there existed consensus and disagreement among science teachers, supervisors, and teacher educators concerning their effective science teaching. Such a determination would enable the science education community to better focus its efforts to develop programs in science education which hold greater promise in impacting upon the quality of science teaching in the schools.

An analysis of science teacher competency research and the criteria employed in assessing the performance of preservice science teachers from a representative sample of major science teacher training institutions facilitated the development of the Science Teacher Competency Sorting Instrument. Subsequent to pilot testing, the instrument was administered to national random subsamples of science teachers, supervisors, and teacher educators. Response data was tabulated and subjected to factor analysis, employing the computer program IMAGEBIG. An initial inspection of the eigenvalues of the correlation matrix set the optimal number of factors to be extracted and rotated at eleven. Following the equimax rotation, competency growth statements and demographic variables loading to a significant degree on the eleven factors were analyzed in order to determine if the associations could lead to factor designations. Contrast vectors were established between the perceptions of the science teachers and those of the remaining science educators, and between the perceptions of the science supervisors and those of the science teacher educators. The magnitude and polarity of the factor loadings of these contrast vectors permitted the determination of those factors for which there was either consensus or disagreement among the science educator subsamples as to the perceived relative importance of growth within them for effective science teaching.

Of the eleven factors generated, two factors associated demographic variables and nine factors subsumed competency growth statements. The factor designations were found to correspond to the more global categories of competencies specified a priori in earlier studies while being themselves more descriptive and precise. While consensus among the science educator subsamples was established for the relative importance of most factors to effective science teaching, there existed disagreement in their attributions of importance to growth in factors relating to the instructional sphere of science teacher behavior. Science teachers emphasized growth in the technical, generic instructional skills to a greater degree than supervisors and teacher educators, the latter subsample attributing more importance to growth in those competencies which promote greater scientific literacy. Further research into the causes underlying these disparate perceptions would seem well advised.

Session C-3

ACTIVITIES OF THE NARST RESEARCH COMMITTEE

Arthur L. White
The Ohio State University
Columbus, Ohio 43210

Claudia Douglas
Central Michigan University
Mount Pleasant, Michigan 48859

David J. Harmon
Kanawah County School
Charleston, West Virginia 25311

Linda DeTure
Rollins College
Winter Park, Florida 32789

This session will be a review of research under consideration for replication at separate sites throughout the country. Specific details and questions regarding design, sampling, measurement, data collection, and data analysis will be discussed. This session is a part of the development activities of the NSTA-NARST Research Network.

Session C-4

ATTITUDE MEASUREMENT IN AN INNOVATIVE CURRICULUM

Peter E. Pezaro
The Ohio State University
Columbus, Ohio 43210

An innovative geochemistry curriculum for high school chemistry students was introduced in Israel in 1978. The unit was one of several optional units designed to augment the chemistry programme in an attempt to increase the relevance and applicative nature of the chemistry being taught in the schools.

Over 500 students participated in the field testing of the unit. Significant cognitive advances were measured using objective and short answer measurement instruments. Affective changes were also measured in the quasi-experimental pre-post design.

The affective instrument chosen for the study was the semantic differential. Three concepts were used: chemistry, science, and geochemistry. Seventeen scales were used. The data were subjected to common factor analysis and six factors were deduced. Summation of the scales within each factor enabled the assignment of suitable construct names which in turn facilitated interpretation of the data.

Several important conclusions were drawn from the affective data: (1) students did, indeed, differentiate between the three concepts when completing the instruments; (2) students preferred geochemistry over chemistry on all major constructs; and (3) chemistry was scored lower than science on most constructs. From these results, it can be concluded that this geochemistry option (and by analogy, other optional "extracurricular" courses) has the potential to improve students' attitudes toward chemistry.

Session C-4

THE ANALYSIS OF SCIENCE CURRICULUM POLICIES

Graham W. F. Orpwood
Science Council of Canada
Ottawa, Ontario Canada K1P 5M1

The research described in this paper forms part of a large-scale three-year study of Canadian science education being undertaken by the Science Council of Canada. Of particular concern here are the policy statements or "curriculum guidelines" established by Provincial Departments of Education which specify the nature and direction of the science curricula in Canadian schools. The comparative analysis of such documents is an important part of the Science Council of Canada study.

However, the research has more general significance also. In order that an objective and systematic analysis be conducted, the materials, and the tasks of its development, analysis, and evaluation need to be carefully conceptualized. This conceptualisation, together with a framework for the analysis of any such curriculum policies, form the generalizable products of the research reported in the paper.

The research methodology employed uses the approach first described by Roberts and Russell (1975) and later illustrated in Munby, Orpwood, and Russell (1980), in which philosophical analysis is used to yield theoretical perspectives from which phenomena from educational practice may be systematically examined. In this research, two analyses of the concept of curriculum are used, one drawing on original but hitherto unpublished work of the author and the other on existing analyses of teaching (e.g. Komisar, 1968). These analyses yield conceptual distinctions which enable the construction of analytical frameworks or clue structures. Use of these frameworks is demonstrated through sample analyses and their applicability assessed in the light of this use.

REFERENCES

Komisar, B. Paul. "Teaching: Act and Enterprise." In Concepts of Teaching: Philosophical Essays, edited by C.J.B. MacMillan and Thomas W. Nelson. Chicago: Rand McNelly, 1968.

Munby, A. Hugh; Orpwood, Graham W.F.; and Russell, Thomas L. Seeing Curriculum in a New Light: Essays from Science Education. Toronto: OISE Press, 1980.

Roberts, Douglas A., and Russell, Thomas L. "An Alternative Approach to Science Education Research: Drawing from Philisophical Analysis to Examine Practice." Curriculum Theory Network, 1975, 5 (2); 107-25.

Session C-4

AN ANALYSIS OF SELECTED NATIONAL ELEMENTARY SCIENCE CURRICULUM PROJECTS USING RALPH W. TYLER'S "BASIC PRINCIPLES OF CURRICULUM AND INSTRUCTION" AS A STANDARD OF COMPARISON

Richard E. Willett
New York University
Washington Square, New York 10003

The purpose of this study was to analyze the process of curriculum development used in the production of selected elementary science curriculum programs produced in the United States during the 1960's. The results help establish the relationship between a conceptual scheme for curriculum development and actual practice. The elementary science curricula that were selected for analysis were: Elementary Science Study (ESS), Individualized Science (IS), Science--A Process Approach (SAPA) and Science Curriculum Improvement Study (SCIS). The process of curriculum development for each of these programs was determined by comparing the written materials of the program to a set of thematic statements produced from a theoretical model for curriculum development.

These statements were produced by a thorough analysis of Tyler's (1949) Basic Principles of Curriculum and Instruction. His rationale for the book is based on the assumption that there are four fundamental areas that must be addressed by anyone engaged in curriculum planning. These areas include: (1) the formulation of objectives; (2) the selection of learning experiences; (3) the organization of learning experiences; and (4) the evaluation of the learning experiences. Tyler provided after each selection a set of general procedures that should be followed. In this study an analysis of Tyler's work revealed 32 thematic areas for the process of curriculum development. A panel of judges attested to the validity of each statement, and the final statements were used to analyze the documents written by each curriculum program. This analysis provided data that enabled this researcher to profile the process of curriculum development for each project.

1. Elementary Science Study. The development of ESS followed Tyler's model most closely in organization of learning experiences, the development of student problem-solving skills, and in program evaluation. ESS was least like Tyler in assessing the needs of the local school group and the individual student and in student evaluation.

2. Individualized Science. The development of IS followed Tyler's model most closely in the development of learning objectives, the organization of learning experiences, the development of student problem-solving skills and positive attitudes in science, and in student and program evaluation. IS was least like Tyler is assessing the needs of the local school group and the individual student.

3. Science--A Process Approach. The development of SAPA followed Tyler's model most closely in the organization of learning experiences, the development of student problem-solving skills, and in student and program evaluation. SAPA was least like Tyler in assessing the needs of the local school group and the individual student, in developing positive student attitudes in science, and in some of the processes related to the development of learning objectives.

4. Science Curriculum Improvement Study. The development SCIS followed followed Tyler's model most closely in the development of learning objectives, the organization of learning experiences, the development of student problem-solving skills and positive attitudes in science, and in program evaluation. SCIS was least like Tyler in assessing the needs of the local school group and the individual student.

Subsequent analysis and comparisons among the projects and Tyler's model have provided several insights into the process of curriculum development utilized in the production of these programs. There is no established relationship between Tyler's model and the actual practice of curriculum development for these projects. There was no commonality among the four projects in curriculum planning. Some of these differences might be due to variation in project goals, project staffs, and the documents available for analysis. The results of this study also indicate that the field of curriculum development is, in Kuhn's (1970) terms, preparadigmatic.

REFERENCES

Tyler, R. W. Basic Principles of Curriculum and Instruction. Chicago: The University of Chicago Press, 1949.

Kuhn, T. The Structure of Scienctific Revolutions (2nd. Ed.) Chicago: The University of Chicago Press, 1970.

GENERAL SESSION I

THE PLACE OF NON-QUANTITATIVE RESEARCH IN SCIENCE EDUCATION

Douglas Roberts
Ontario Institute for Studies
in Education
Toronto, Ontario Canada M5S 1B6

Session D-1

AN INVESTIGATION OF THE ROLE OF PIAGETIAN MENTAL OPERATIONS ON EARTH SCIENCE CONCEPT ATTAINMENT IN A DIFFERENTIATED INSTRUCTION MODEL FOR CONCRETE AND FORMAL LEVEL SUBJECTS

Gabriel M. Ziccarelli
G. W. Moser
University of Pittsburgh
Pittsburgh, Pennsylvania 15260

It has been established by science education researchers that Ss have improved learning efficiency if differentiated learning is provided through science instruction. The purpose of this investigation was to replicate a differentiated learning model in order to determine the role of Piagetian operativity of Ss in their concept attainment on a delayed task designed to measure learning.

The sample of 135 ninth-grade Ss was given a Piagetian battery designed for assigning Ss to groups homogeneous with respect to developmental stages. The stage level Ss were then matched or mismatched in receiving units prepared for concrete or formal stage Ss. The seashores units consisted of three lessons of verbal material. Treatment time was one week.

A twenty-item objective concept test was administered prior to and again immediately after the instructional treatment. The same instrument was used one week later. The Ss also completed two Piagetian task batteries emphasizing figural and verbal perceptional forms prior to the instructional aspect of the study.

It was found through analyses of variance that groups of Ss had significant increases in their performance as a result of instruction given on a differentiated basis. However, there was no significant effect of treatment differences accorded to formal level Ss, i.e., whether or not they were given units designed for either stage of Ss.

A linear detrending technique was used to isolate the cognitive veracity of Ss performance on the delayed objective test. This dependent variable was used for its prediction of operations defined in a Piagetian model. It was found that particular operations were specific to the stage of development of Ss and the mode of instructional treatment administered to them.

This investigation is a landmark in science education research in that it was designed for isolating that operativity of Ss which influences delayed memory performance on an objective concept test. The conclusion drawn from the investigation is that regardless of the differentiated learning treatment modes offered Ss, their structural mental operativity has a major role in the measurement of delayed concept storage and retrieval.

Session D-1

A LINEAR PATH MODEL OF DELAYED PROSE RECALL OF A LECTURE ON RADIATION EFFECTS

G. W. Moser
Helen M. Loughner
University of Pittsburgh
Pittsburgh, Pennsylvania 15260

One of the major problems in science education research is determining the remembrance students have of lecture forms of science knowledge. It is particularly difficult to measure verbal recalls, such as in prose presented by students.

The purpose of this investigation was to develop a model of prose recall with linear, path-like characteristics. It was assumed that key words Ss use in writing their recall had these characteristics.

The experiment schedule required high school chemistry Ss (N=54) to listen to a 15 minute audiotape on the biochemical effects of nuclear radiation. Ss then wrote a recall and completed an objective test of 20 items. Ten minutes were allowed for each activity. The Ss then completed an unscheduled prose recall one week later.

The prose recalls were analyzed for the words most frequently used by the Ss. There were 1267 different words in the recall. The 13 words with highest frequencies were tested by identifying an equal number (N=14) of words in the lexicon that were needed to complete a path-analytic model of the immediate recall.

Facilitation in delayed remembrance due to psychometric intelligence was for the words "breast, cloud, one." The set of delayed recalls, due to performance on the earlier objective test, was the words: "burn, breast, genetic, measure, medium, radiation, two."

The LTM model was analyzed for retroactive recovery, association learning, association recall, and forgetting. Twelve LTM model words ("bomb, die, exposure, kidney, measure, one, people, radiation, suffer, two, was, week") were linearly related to the total words Ss used in the immediate recall. Sixteen percent of the variance in matched association, delayed recall of words was explained by their use in the immediate recall. Between 45 and 99 percent of the variance in delayed recall words was explained by the canonical of immediate prose recall words. Significant predictions were made for the words: "appetite, breast, burn, cloud, effect, exposure, genetic, kidney loss, medium, particle, people, radiation, suffer, week."

The linear effects of the immediate recall lexicon were removed in order to characterize an endogenous path model for delayed recall. It was found that two-thirds of the linear operator effect, e.g. significant correlations, were not due to the immediate prose recall words.

These results indicate a prose recall model existed for remembering a 15 minute lecture on radiation effects. It was concluded that the model demonstrates the phenomena of association, comprehension, and facilitation of cognition.

Session D-1

THE DISCRIMINABILITY OF STUDENT TRAITS AND ENERGY OPINIONS FOR FINAL CHEMISTRY COURSE GRADES

Helen M. Loughner
G. W. Moser
University of Pittsburgh
Pittsburgh, Pennsylvania 15260

There has been considerable research on the subject achievement of Ss, but there is no report of the role of words used to express their opinion on the energy situation. The purpose of this investigation was to compare the role of opinions with that of variables normally used in achievement studies.

The sample of 54 chemistry students ($\bar{X}$ = 16.4 years) wrote two statements in December and again in the month of May, on the opinion of the energy situation. The opinion variables were selected in terms of the 25 most frequently used key words. They also completed an inventory of dogmatism, an abstract reasoning test, and an intelligence test. The Ss maintained a log of hours/week spent in activities: reading newspapers, working, studying chemistry, overall studying, and leisure. They completed preference forms for types of television programs, radio music, and subjects in high school. Finally, the Ss completed a home environment inventory. The eight sets of trait variables and two sets of opinion words were used in a discriminant analysis of the final chemistry course grade.

A stratified discriminant analysis was done to compare the role of the eight achievement trait sets with that of words used in prose opinions on the energy situation. Eight analyses were done for the discriminiation of the final chemistry grade (A, B, C, D) of the Ss. Six of the eight sets contained variables which significantly separated grade swarms. The non-significant discriminators were for the amount of time spent per week in studying and in leisure activities. The principal discriminator variable was the dogmatism of the Ss; 50 percent of the course grade cases were correctly classified by its function. The next most discriminating variable was the IQ of Ss (correctly classifying 46.3 percent). The major discriminators of the other variable sets were: (1) the preference of taking physical education; (2) liking TV variety shows; (3) listening to classical radio music; (4) the number of hours/week spent reading the newspaper; and (5) sibling rank.

The principal chemistry course grade discriminator of the winter opinion statements was the word "coal." It correctly classified 41 percent of the chemistry grade cases. The principal spring opinion word for the energy situation was "future." This function correctly classified 43 percent of the grade cases.

An analysis was then done using the principal discriminator variable of each set with the number drawn in proportion to the number in each original set. The best discriminator in each of the two analyses was the IQ of Ss. In the analysis of trait variables and winter energy words, the word "coal" was the seventh loader. The canonical of eleven variables correctly classified 76 percent of the course grade cases. The home environment variable (sibling rank) was not found in the canonical. The spring opinion words "gasoline" and "future" were the second and third best discriminators in the second analysis. The trait variables of sibling rank and preference for physical education failed to enter into the second analysis load. There were 74 percent of the cases correctly classified by the function of the canonical of nine independent varibles.

The results of this investigation indicate that opinions of Ss do significantly discriminate for chemistry achievement. Although the IQ of Ss was found to be the major discriminator, the words Ss use in expressing opinions of the energy situation are also significant discriminators ($p \leq .01$ as an approximation of Wilks' Lambda) of chemistry achievement. The fact that the opinion word variables were competitive with other traits of Ss indicate that there is a need to explore opinions as to their influence on science achievement.

There may be some question of the generalizability of this claim. The Ss were volunteers for the project, yet may be regarded as representative of their age-grade population. The difference of words in opinions which were significant discriminators of final chemistry grades indicates, that as moderator variables, there were different roles of opinions Ss held with regard to achievement. This finding could be construed as meaning there is some constructive validity for the role of opinions in Ss obtaining a final grade in a chemistry course.

Session D-1

THE DISCRIMINABILITY OF MATHEMATICS AND SCIENCE ACHIEVEMENT BY MUSIC INTERESTS AND PRACTICES OF VOCATIONAL EDUCATION STUDENTS

Edward T. Hrabal
G. W. Moser
University of Pittsburgh
Pittsburgh, Pennsylvania 15260

The purpose of this study was to determine whether or not the music interest and practices of vocational/occupational Ss discriminated for physical science and mathematics final course grades. The investigation was prompted from the paucity of research done on the role of aesthetic pursuits in science and mathematics achievement.

The volunteers (N=79) for this study were enrolled in an occupational/vocational education feeder school program. They completed a ten item inventory of music interests and practices designed for scaled option responses. The Ss (Mean age=17.2 years) were also administered an abstract reasoning test. The dependent variables were final course grades in non-academic science and mathematics.

The music preference (classical, rock, etc.) of Ss was the principal discriminator of both mathematics and science grades. Between 39 and 81 percent of the cases were correctly classified for grade swarm membership, depending upon grade level groupings (A plus B; C, D plus E, as an example). Seven of the 10 inventory variables entered into the discriminant analyses. Significant discriminant canonical functions correctly classified from 53 to 84 percent of the grade swarm memberships. Discriminability of science and mathematics course grades differed in terms of the activeness of music interests. The form of music (tapes, records, etc.) collected was a significant discriminator only in analyses of mathematics grades. On the other hand, unique discriminators of science grades were music practices, such as type of instruments Ss played or the Ss singing preferences. The abstract reasoning ability of Ss was the principal discriminator, when entered into the analyses with the music inventory variables. The reasoning variable improved the correct classification of grade memberships by up to 8.4 percentage points.

The conclusion was that music interests and practices of non-academic track Ss significantly discriminate for achievement in science and mathematics. This discovery indicates that further research should be done regarding the role of aesthetics in science and mathematics achievement.

Session D-2

REPRESENTING THE SUBSTANTIVE STRUCTURE OF DISCIPLINES

Fred N. Finley
University of Wisconsin
Madison, Wisconsin 53706

In the early 1960's Schwab (1962) introduced the idea that disciplines were composed of substantive and syntactic structures. He argued that educators ought to consider the structure of disciplines in developing curricula so that the content presented to students would be correct, coherent, and complete. However, since Schwab introduced the structure of the disciplines, there have been no elaborations of the meaning of that phrase. One reason Schwab's research has not been extended is the lack of precise techniques for describing the structure of disciplines. The purpose of this paper is to present techniques for describing three aspects of substantive structures and related curriculum and research implications.

The first technique is for specifying the underlying meaning of substantive structures using active structural networks (Norman and Rumelhart, 1975). Active structural networks involve the use of predicates that specify the relations that might exist among some set of concepts. Predicates correspond closely to verbs, adjectives, and adverbs, and take a prescribed set of arguments that are usually nouns. Using a limited set of predicates such as CHANGE and CAUSE, it is possible to describe the meaning of substantive structures from disciplines as detailed networks of propositions.

Substantive structures also can be represented by classifying the concepts of a discipline as to the logical relationships among them. Smith (1972) proposed a set of classification schemes for doing this called analytic networks. An analytic network is a set of individual analytic concepts that have been abstracted from conceptual systems to represent the logical features of those systems. For example, the variable-value network can be used to categorize concepts involving the variables, variable values, and measurement procedures for describing physical objects. Taken together a set of analytic networks can be used to describe major portions of science discipline.

A third way of describing substantive structures is to categorize propositions as to the epistemological nature. Hempel (1952, 1965) and Carnap (1966) have described several types of propositions included in science descriptions, explanations, and predictions: facts, hypotheses, empirical laws, theoretical assumptions, and bridge principles. The categories are based on the types of concepts they included (empirical or theoretical) and the function of the proposition in the discipline. By categorizing propositions in these terms science educators can better understand the epistemologic structure of the discipline.

Science educators are obligated to develop curricula that are complete, coherent, and correct. Throughout the processes of identifying, selecting, and sequencing content, the structure of the discipline from which the content derives must be maintained. The above three approaches to describing substantive structures can contribute to this process by increasing the precision with which the meaning of the structures, logical relationships among concepts, and epistemologic nature of proposition can be described. Similarly, in science education research the substantive structures of disciplines should be considered. The three views of substantive structures just described should be useful in any research where science content is a factor that needs to be described, controlled, or systematically varied.

REFERENCES

Carnap, R. Philosophical Foundation of Physics. New York: Basic Books, Inc., 1966.

Hempel, C. G. Aspects of Scientific Explanation and Other Essays in the Philosophy of Science. New York: The Free Press, 1965.

Hempel, C. G. Fundamentals of Concept Formation in Empirical Science. Chicago The Chicago Press, 1952.

Norman, D. A. and Rumelhart, D. E. Explorations in Cognition. San Francisco: Freeman Press, 1975.

Schwab, J. J. "The Concept of the Structure of a Discipline." Educational Record, 1962, 43: 197-205.

Smith, E. L. "Analytic Networks and Task Domains for a Primary Grade Science Curriculum." In D. W. Bessemer and E. L. Smith (eds.), The Integration of Content, Task, and Skills Analysis Techniques in Instructional Design. Los Alametos, California: SWRL Educational Research and Development, 1972.

Session D-2

YOUNG ADULTS TRUST IN INFORMATION SOURCES ABOUT SCIENCE POLICY ISSUES

Alan M. Voelker
Northern Illinois University
DeKalb, Illinois 60115

This paper develops a model for predicting high school and college students trust in information sources about science policy issues. The data were produced from a national survey of over 4000 students. Factor analysis and other index construction techniques are used to construct trust indices dealing with people, agencies, and media. Variables associated with science knowledge, interest, and attitudes; family and school activities; people and politics; personal and religious values; school and career plans; and the person and the family are employed in cross-tabulation and log-linear analysis to develop the predictive model.

Session D-2

PREPARING AND USING DATA TAPES AND MACHINE READABLE USERS GUIDES: A NEW RESOURCE FOR SCIENCE EDUCATION RESEARCH*

James T. Robinson
Center for Educational
Research and Evaluation, BSCS
Boulder, Colorado 80306

The development and use of meta-analysis procedures (Glass, 1978) in investigating research data from many studies have demonstrated the value of ex post facto analysis. However, the limitations of using statistical data for ex post facto analyses suggest the value of having research data banks that contain raw data and documenting the data contained in these banks for use in subsequent analyses.

This paper reports the preparation of a data tape and users guide. The tape contains about 700 cases with nearly two thousand variables collected over a three-year period as part of a curriculum evaluation study. The student group is the eleven- to fourteen-year old population that participated in the field test of the BSCS Human Sciences Program.

Data tapes are a common research resource in the social and natural sciences, but have had limited use in science education research. Preparation of tapes and users guides so that they can be transferred among the various computer systems requires those making tapes to follow certain procedures. Without attention to these procedures transferability to different computers can be costly.

Users of tapes will find that the types of data that can be provided include comparative data, and original data for master's degree and doctoral research, as well as a rich source for various types of professional investigations.

The next decade should see a large increase in the availability of data that can be shared among investigators for enriching the quality of users and producers of these research tools.

REFERENCE

Glass, Gene V "Integrating Findings: The Meta-analysis of Research." In L. S. Shulman (ed.). Review of Research in Education (Vol 5), Itasca, Ill.: Peacock, 1978.

*The research reported here is supported by grant SED-79-19312 from the National Science Foundation.

Session D-3

NARST - ERIC/SMEAC

REVIEW OF RESEARCH

IN SCIENCE EDUCATION - 1979

David P. Butts
University of Georgia
Athens, Georgia 30602

This report will review and summarize the research in science education as reported in the literature in 1979. The review is organized as a search for an order of ideas, a search for relevant variables in the science learning context. With these variables we can then both understand and nurture scientific literacy.

The order of the science learning environment seems to depict three components. There is the personal interaction among teacher and students; this interaction is part of an instructional interaction that includes both the content and the methodologies used. Surrounding these interactions are the expectations of schools as they reflect what society in general expects these institutions to accomplish.

This report, then, will examine the use of research to understand the science learning context by considering the order of ideas in research in science education and the research strategies used to find science education's order of ideas. The review is organized to include: Searching the Science Learning Context of the Elementary School Student; Searching the Science Learning Context of the Emerging Adolescent; Searching the Science Learning Context of the Adolescent; Searching the Science Learning Context of the Undergraduate Collegian; Searching the Context of the Science Teacher; Measurement Instruments for Research in Science Education; and, Looking Backward to Look Forward. The research within each of the contexts described is examined as it focuses on the student filter, the teacher filter, the instruction filter, or, their interaction.

Session D-4

THE SELECTIVE FACILITATIVE EFFECTS OF CONCRETE ORGANIZERS AND ABSTRACT ORGANIZERS ON TARGETED ACHIEVEMENT GROUPS' LEARNING

Edward E. Jones
Miami University
Oxford, Ohio 45056

Rationale and Purpose

According to subsumption theory, cognitive structure has a foundation of highly inclusive and relatively stable concepts (Ausubel, 1960). As new learning occurs, it is processed and categorized under existing concepts but becomes meaningful only to the extent that existing related concepts are clear and stable in the mind of the learner. If subsumption theory can be shown to be a credible model of learning, then there are significant implications for science teaching and curriculum writing.

Previous investigations with advance organizers have shown mixed results (Barnes and Clawson, 1975). The purposes of the present study were as follows:

1. To determine if an advance organizer prepared with abstract content would facilitate learning for students scoring at or above the sixth stanine on the science section of the SAT, but fail to facilitate learning for students scoring at or below the fourth stanine.
2. To determine if an advance organizer prepared with concrete content would facilitate learning for students scoring at or below the fourth stanine on the science section of the SAT but fail to facilitate learning for students scoring at or above the sixth stanine.

Two advance organizers and a placebo introduction were used. Each was an eight and one-half minute tape/slide presentation prepared as introduction to the concept of feedback. One organizer was relatively abstract and was labeled the abstract advance organizer (AAO). The second organizer was relatively concrete and was labeled the concrete advanced organizer (CAO). Control groups received a placebo introduction (PI).

Methodology and Procedure

Ss for the study were eleventh-grade students in one of six "Science and Technology" classes. Ss from each ability group were randomly assigned to receive one of the prepared introductions. After treatment they rejoined their classmates for four class periods of instruction on the concept of feedback, followed by an unannounced 24-item performance exam.

Results and Conclusions

A one-way ANOVA applied to the exam scores of higher ability Ss indicated significant differences at the .001 level of confidence. A Scheffe' test of group comparisons indicated that the AAO group scored significantly higher than either the CAO or the PI groups ($p \leq .01$). The CAO group scores were not significanly different from the PI group scores.

A one way ANOVA applied to the exam scores of lower ability Ss indicated significant differences at the .01 level of confidence. A Scheffe' test of group comparisons indicated that the CAP group scored significantly higher than either the AAO or the PI groups ($p \leq .05$). The AAO group scores were not significantly different from the PI group scores. Ability level by treatment interaction effects suggest that advance organizers may be facilitative only for a relatively narrowly defined collection of learners. If advance organizers are to aid the subsumption of new material, it may first be necessary for them to conform to the preparedness and scholastic ability of the learners.

REFERENCES

Ausubel, D. P. "The Use of Advance Organizers in the Learning and Retention of Meaningful Verbal Material." Journal of Educational Psychology, 1960, 51: 267-72.

Barnes, B. R., and Clawson, E. U. "Do Advance Organizers Facilitate Learning? Recommendations for Further Research Based on an Analysis of 32 Studies." Review of Educational Research, 1975. 45: 637-659.

Jones, E. E. "The Effects of Advance Organizers Prepared for Specific Ability Levels." School Science and Mathematics, 1977, 77: 385-90.

Session D-4

THE EFFECTS OF DEGREE OF CONCEPT RELATEDNESS OF INSTRUCTION AND LOCUS OF CONTROL ORIENTATION ON THE MEANINGFUL LEARNING ACHIEVEMENT OF HIGH SCHOOL BIOLOGY STUDENTS

Jacqueline D. Sherris
Baltimore, Maryland 21212

Meaningful learning as defined by David Ausubel (1960) involves the linkage of new ideas to existing concepts and principles in a learner's knowledge structure. Instructional strategies which place explicit focus on the relationships between new ideas and established ideas should enhance meaningful learning. Few Ausubelian-related studies have addressed the mediating effects of individual difference variables on instructional sequences designed to enhance meaningful learning. Locus of control orientation, the extent to which individuals feel that reinforcement is contingent upon fate, luck, or powerful others, is a variable which may have important school learning effects. Individuals with an internal locus of control orientation may not respond to specific external learning cues as readily as subjects with an external locus of control orientation. The purpose of this study was to examine any interaction effect which may be present between degree of concept relatedness of an instructional sequence and locus of control orientation as measured by meaningful learning test scores.

The design of the study was quasi-experimental since instructional treatments were randomly assigned to established classes rather than to individual subjects. Five hundred and forty-one ninth- and tenth-grade subjects from six Indiana high schools were involved in the study. The two human biology-related instructional treatments consisted of a study guide, a reading supplement, and an activities supplement. The difference between the treatments was the presence of conceptual cues and concept mapping exercises in the experimental study guide. Locus of control was evaluated through the adult Nowicki-Strickland scale. Meaningful learning achievement was evaluated through three alternate form tests (pre-test, post-test, and retention test) made up of application level questions.

Two-way analyses of covariance (ANCOVA) by treatment and locus of control were performed on post-test and retention test scores with pre-test as the covariate. For both analyses, the treatment effect was not statistically significant and the locus of control effect was statistically significant. The treatment x locus of control interaction effect was statistically significant with retention test scores only. External subjects in the experimental group retained more information than external subjects in the comparison group whereas internal subjects retained about the same amount of information regardless of treatment group. When this analysis was performed on female and male subjects separately, it was found that the treatment x locus of control interaction effect for retention test scores was statistically significant for females, but not for males.

Subjects who felt that their lives were controlled by external forces seemed to have been more responsive to the external learning cues present in the experimental instructional sequence than subjects who were confident that their own actions determined academic success. The fact that the interaction effect was not present with post-test scores may reflect initial learning shock effects precipitated by recent exposure to many new ideas. The six week time period between completion of instructional materials and administration of the retention test would have reduced this learning shock effect without affecting meaningfully learned concepts. Externally oriented females may have been more responsive to external learning cues than externally oriented males because of socialization differences between the sexes. Further investigations should be able to clarify this suggestion.

REFERENCE

Ausubel, D. P. "The Use of Advance Organizers in the Learning and Retention of Meaningful Verbal Material." Journal of Educational Psychology, 1960, 51: 267-72.

Session D-5

NONPARAMETRIC STATISTICAL TECHNIQUES FOR SCIENCE EDUCATORS

Robert D. Sherwood
New York University
New York, New York 10003

Recent trends in educational research have indicated that a variety of skills are needed for researchers to most completely investigate an area. Many times inquiry results in the collection of data that do not meet the assumptions of classical parametric statistics. Such instances often occur in survey, attitudinal, and interview studies.

The session will attempt to broaden researchers knowledge of nonparametric techniques by providing examples of nonparametric techniques that correspond to classical parametric techniques (t-tests, ANOVA, repeated measures ANOVA, and measures of association). SPSS computer examples and procedures for hand calculation will be discussed as well as the assumptions and power of nonparametric techniques.

Session E-1

TRENDS WITH RESPECT TO SCIENCE TEACHER EDUCATION, FACULTY, AND PROGRAMS

John E. Penick
The University of Iowa
Iowa City, Iowa 52242

Rodger Bybee
Carleton College
Northfield, Minnesota 55057

Ertle Thompson
University of Virginia
Charlottesville, Virginia 22903

Program descriptions, faculty vitae, and trends that can be identified in Science Teacher Education in the U.S. during the last two decades (1960-80) will be reported. Questionnaires have been distributed to all institutions of higher education; all those with known preparatory programs will be contacted again if the information needed for comparisons is not available.

The information attained will be analyzed for trends noting differences in 1960, 1965, 1970, 1975, and 1980. The information sought parallels similar information reported as a part of the NARST-NSF Status Study of Graduate Centers of Science Education (Yager, 1980). The information will complete the extensive studies of the status of science education which were begun in 1977 with the three major NSF status studies of K-12 science education.

REFERENCE

Yager, Robert E. "Status Study of Graduate Science Education in the U.S. 1960-1980." Iowa City, Iowa: Science Education Center, University of Iowa, September 15, 1980.

Session E-1

FOLLOW UP OF THE NSF STATUS STUDY OF GRADUATE CENTERS OF SCIENCE EDUCATION IN THE UNITED STATES, 1960-80

Edward L. Pizzini
Robert E. Yager
The University of Iowa
Iowa City, Iowa 52242

Kenneth W. Dowling
Wisconsin Department of Public Instruction
Madison, Wisconsin 53702

Charlotte Purnell
Delaware Technical and Community College
Dover, Delaware 19901

As a followup of the NSF Status Study of Graduate Centers of Science Education in the U.S., 1960-80, this study involved the leadership in science education found in state departments of education during the twenty year period. Information concerning numbers of full-time equivalents in each state during the twenty years, the previous professional experience of each person, the educational preparation of each person, and the assigned responsibilites in each department are being tabulated and analyzed.

The results will be compared with similar trends and data from graduate centers, other college departments, secondary school supervisors of science, and department chairs. This added information will provide a means for better assessing the status of science education in 1981; it will provide a means for analyzing the major problems and the needed solutions in science education, 1980.

Session E-1

CHARACTERISTICS OF 168 FACULTY MEMBERS AT 35 MAJOR GRADUATE CENTERS FOR SCIENCE EDUCATION

Robert E. Yager
The University of Iowa
Iowa City, Iowa 52242

Eric E. Zehr
Kennedy Senior High School
Cedar Rapids, Iowa 52403

Rodger Bybee
Carleton College
Northfield, Minnesota 55057

The NSF Status Study of Graduate Science Education in the United States, 1960-80 identified thirty-five major centers where most of the research is accomplished and most of the new doctoral graduates are produced. The study reveals that these thiry-five centers employ a hundred and sixty-eight faculty members. This is a report of the educational backgrounds, the experience backgrounds, length of service, academic rank, professional involvement, and scholarly productivity. It represents the next phase of the studies reported in the general session at the 1980 NARST meetings in Boston.

Session E-2

AN ANALYSIS OF THE RELATIONSHIP OF STUDENTS' SELF CONCEPTS IN SCIENCE AND THEIR SCIENCE ACHIEVEMENT, MENTAL ABILITY, AND GENDER

Burt A. Sellers
Tonawanda Senior High School
Tonawanda, New York 14150

The purpose of this study was to further investigate (Doran and Sellers, 1978) the relationship between students' self concepts in science and their science achievement, mental ability, and gender. These relationships were viewed in the theoretical writings of Maslow (1954), the client-centered framework of Rogers (1951), and in the phenomenology of Combs and Snygg (1959).

Based on theoretical constructs and a review of relevant research, it was hypothesized that there would be a positive relationship between students' self concept in science and a measure of achievement in science and their mental abilities. It was further postulated that students' self concepts in science would be positively related to measured achievement in science when mental ability was partialled out. In addition, males were hypothesized to have higher self concepts in science than females.

All subjects (N=214) were chosen from the sophomore class of a central public high school located in an urban community of Western New York. The Self Concept in Science Scale (SCSS) was used as a measure of students' self concepts in science. Science achievement was measured by the students' Tenth Grade Final Examination in Biology. The measure of the mental ability used was the Otis-Lennon Mental Ability Test, Advanced Form, J. Demographic data were obtained from guidance folders and a student questionnaire.

An analysis of the data was made by a stepwise multiple regression. The results appear to confirm the hypothesis that a relation does not exist between students' self concepts in science and a measure of science and their mental ability and grades. Bivariate correlations between the criterion variables of self concept in science and the predictor variables of measured biology achievement and mental ability were significant and positive ($\rho \leq .05$). The bivariate correlation between self concept in science and grades was not significant. The hypothesized relationship between students' self concept in science and their "differential achievement" (mental ability partialled out) and grades were supported by the data obtained.

The major conclusion drawn from the results of the study is that students who are high achievers in biology achievement and who have high mental ability will have the highest self concepts in science. This conclusion supports the theoretical construct that the perceptual field as perceived by the individual has a specific determining effect on behavior, as well as what may be assimilated

into the self. The person with a positive self concept in science can enter the science classroom expecting to be successful, and, therefore, act in ways that will bring about success. The individual expecting failure will have a limited number of alternatives to choose from in a problematic situation.

REFERENCES

Combs, W. and Snygg, D. Individual Behavior (2nd ed.) New York: Harper and Row, 1959.

Doran, R. and Sellers, B. "Relationships Between Students' Self Concept in Science and Their Science Achievement, Mental Ability, and Gender." Journal of Research in Science Teaching, 1978, 15 (6): 527-533.

Maslow, A. H. Motivation and Personality. New York: Harper, 1954.

Rogers, C. R. Client-Centered Therapy. Boston: Houghton Mifflin Company, 1951.

Session E-2

SEX-ROLE STEREOTYPES, INTEREST IN SCIENCE, AND RESPONSES OF SIXTH-GRADERS TO SCIENTISTS/ TECHNOLOGISTS ON T.V.'S "3-2-1 CONTACT"

Marcia Kaplan Rudy
New York University
Washington Square, New York 10003

Recent studies have concluded that appropriate role models are important in increasing interest and participation of girls in science. Exposing children, especially girls, to nonstereotypic views and broader options regarding interest in science is a means of familiarizing and involving them with an area that is accessible and open to their participation. A new televison series, "3-2-1 Contact", responds to this need by providing girls with a host of male and female role models of scientists and technologists of all ages who enjoy their scientific involvement. These role models present much of the science content of the show by describing and demonstrating scientific principles.

This study investigated children's responses to the "3-2-1 Contact" science/technology role models in relation to the gender, sex-role stereotype, and interest in science of these children. During the spring of 1980 approximately 150 urban sixth-graders viewed the half hour Friday summary show of each of the 13 weeks of "3-2-1 Contact" (available on video cassette) during school hours in classroom settings. Prior to the first viewing a group of measuring instruments were administered. Self perceptions of sex-role trait stereotypes were measured in terms of scores on the masculine and feminine subscales of the Extended Intermediate Personality Attributes Questionaire (EPAQ-I) (Spence and Helmreich, 1978a). Sex-role trait stereotypes of males and females in general were measured in terms of scores on the masculine and feminine subscales of the Extended Intermediate Personality Attributes Questionnaire Trait Stereotype Measure (EPAQ-I TSM) (Spence and Helmreich, 1978b). Interest in science was measured in terms of scores on the mechanical and investigative subscales of the Interest in Science Scale (ISS). Written responses to a male and female science/technology role model were collected after viewing each of the six shows. Responses were averaged for shows 2,3,4 (the beginning of the series) and shows 11,12,13 (the end of the series). The Response to Role Model Scale assessed the attention and attitude and the appeal of the six male and six female role models. Following the viewing of the 13th show the two sex-role stereotype instruments and interest in science scale were readministered.

Two primary questions were investigated:

1. What are the differences between boys and girls in relation to stereotypic self-definition (in terms of masculine and feminine trait stereotypes), stereotypes of males and females, and interest in the mechanical and investigative aspects of science.

2. What are the differences between boys and girls in relation to responses to same-sex and opposite-sex role models?

Multivariate analysis of variance was used to examine the relationship between the independent variables gender and time of testing, and the dependant variables stereotypes and interest in science for question 1. Multivariate analysis of variance was used to examine the relationship between the independent variables gender, time of testing, and sex of role model and the dependent variables responses to role models for question 2.

In regard to sex-role stereotypes and interest in science, boys saw themselves and other males as more masculine than did girls. Boys had greater interest in mechanical aspects of science. Boys went down in mechanical interest and girls went up following viewing of the series.

In regard to the responses to the role models, boys preferred and remembered more about the males, while girls preferred and had higher opinions of the females. Attention was greater to role models at the beginning of the series. Both appeal and attitude were greater for the female models at the beginning and the male models at the end. An exploration of the specifics of who these models were, how they were presented, the kind of science work they do, as well as implications of the study's findings will be discussed.

REFERENCES

Spence, Janet T. and Helmreich, Robert. Extended Intermediate Personality Questionnaire. University of Texas, September 20, 1978a. Available from the authors, Department of Psychology, Austin, Texas 78712.

Spence, Janet T. and Helmreich, Robert. Extended Intermediate Personality Attributes Questionnaire Trait Stereotype Measure. University of Texas, September 20, 1978b. Available from the authors, Department of Psychology, Austin, Texas 78712.

Session E-2

COGNITIVE CORRELATES OF SEX-RELATED DIFFERENCES IN PERFORMANCE IN COLLEGE BIOLOGY

Daniel Dobey
Mount Saint Mary's College
Emmitsburg, Maryland 21727

William Doody
The American University
Washington, D.C. 20016

Objectives

This is the third in a series of studies pertaining to determining the interdependence of sex-related cognitive differences and performance in science. In the first study, a sex-related difference was identified between a Spatial Ability test and performance in high school biology. The reasons for the noted differences were not clear. In the second study, the Spatial Ability test was decomposed into constituent elements via analyses using Piagetian tasks. Two of six Piagetian tasks were identified as significant sources of sex-related differences on the Spatial Ability test. In this, the third study, the significant Piagetian tasks, and the Spatial Ability test, were used to further analyze sex-related differences in performance in science. The objective of the third study of the series is to identify sex-related cognitive differences which are highly correlated with performance differences in college biology.

Methodology

The Group Embedded Figures Test (GEFT) and the Piagetian tasks on Spatial Functions and Pseudo-Conservation were administered to 35 male and 35 female first year college biology students (non-science majors) during their first academic week. Performance was monitored over a three month period which included four units of study. Two units focused on descriptive content; instruction in one of these units included the use of films and emphasized visual skills; instruction in the second unit included discussion groups and reading. Two units focused on quantitative-analytic content; one of these units emphasized visual skills and the other emphasized discussion groups and reading.

Results

For the combined sample, stepwise multiple regression was used to determine which test (Spatial Ability, Spatial Function, Pseudo-Conservation) accounted for the greatest amount of variance in performance in each unit. Part and partial correlations were computed; the unique contribution of each test to performance was thereby determined. For the divided sample (males, females), stepwise discriminant analysis was used, whereby the relative importance of Spatial Ability, Spatial Function, and Pseudo-Conservation as discriminators between sexes was determined. The results of these analyses were:

(1) Spatial Function (SF) accounted for the greatest portion of variance in performance; SF was significantly correlated with performance in those units emphasizing quantitative-analytic content. (2) Spatial Function was the best discriminator between the sexes; the difference between sexes was significant. (3) Pseudo-Conservation was found to be more highly correlated with those units calling on visual skills than those units calling on language skills.

Conclusion

Sex-related differences in Spatial Function, which are readily interpreted in terms of specific logical operations, are significant correlates of sex-related difference in performance in biology. This suggests that the often noted sex-related difference in Spatial Ability (which correlates highly with sex-related differences in performance in science) may be a function of logical operations rather than of an ability to form mental images per se. Similarly, sex-related differences in disembedding skill (focusing of attention on appropriate elements of a stimulus display) may be a function of logical operations. Instructional strategies should, therefore, focus on development of logical skills rather than imagery skills.

Session E-3

AN HOUR WITH THE JOURNAL EDITOR

James A. Shymansky
The University of Iowa
Iowa City, Iowa 52242

Questions about editorial policy and the mechanics of processing manuscripts for The Journal of Research in Science Teaching will be discussed and answered.

Session E-4

COGNITIVE STYLE AND THE EFFECTS OF TWO INSTRUCTIONAL TREATMENTS ON THE ACQUISITION AND TRANSFER OF THE ABILITY TO CONTROL VARIABLES: A LONGITUDINAL STUDY

Barbara M. Strawitz
Louisiana State University
Baton Rouge, Louisiana 70803

Is it worth the effort to teach sixth-grade students to acquire and transfer the ability to control variables? The effort can be justified if it can be shown that the time required for instruction is reasonable, that the treatment effects are retained by students over a long time interval, and that students will not acquire the ability over the same time period without instruction.

In an earlier study (Strawitz, 1980) the neoPiagetian theory of Pascual-Leone (1970) was used to predict successfully that both field dependent (FD) and field independent (FI) sixth graders could be taught to control variables and to transfer this ability to novel tasks. The purpose of the present study was to assess long-term retention effects (one year) of the two methods of instruction used in the sixth-grade investigation and to compare the abilities of instructed and uninstructed seventh-grade students to control variables.

Seventy-four seventh-grade students enrolled in two schools serving predominantly middle-class areas participated in the study. They were given the Group Embedded Figures Test (Witkin, et al., 1971), classified as FI or FD, and assigned to one of three groups. Students in Group I had been taught to control variables in three 25-minute sessions while in the sixth grade with an instructional method adapted from Case (1974, 1975) (Treatment I). Students in Group II had worked in an open-ended mode without feedback with the same materials as had Group I for the same amount of time (Treatment II). Students in Group III had not received special instruction and served as a post-only comparison group (Treatment III). The same controlling variables tasks used as delayed post-tests one year earlier with Groups I and II were administered individually to students in the three seventh-grade groups as retention measures. The tasks were bending rods (Inhelder and Piaget, 1958), ramp (Wollman, 1977), and lever (adapted from Bredderman, 1973).

A general linear models procedure with single degree of freedom contrasts was used to analyze data for each retention task. The results of the 2 (treatment) x 2 (cognitive style) x 2 (time) ANOVA with repeated measures on the time factor indicated that Treatment I produced better retention over time for both FD and FI students than did Treatment II. Treatment II was more effective for FI students than for FD students.

Data for the three groups of students were analyzed to compare group means of each task for instructed and uninstructed seventh-graders. The results of a 3 (treatment) x 2 (cognitive style) ANOVA with single degree of freedom contrasts revealed that in general, Treatment I was significantly more effective for the FD students than Treatments II and III; the effects produced by Treatments II and III were not significantly different. For FI students, Treatment II was significantly more effective than Treatment III. The performance of FI and FD students in Treatment I did not differ, but FI students were superior to FD students in both Treatments II and III.

The results of this study indicate that it is worth the effort to teach sixth-grade students to control variables. The method of instruction used in Treatment I for three 25-minute sessions was successful in teaching both FD and FI sixth-grade students to acquire, transfer, and retain the ability to control variables over a one year time interval. The results of the study also indicate that uninstructed seventh-grade students do not generally acquire this ability on their own.

REFERENCES

Bredderman, T. A. "The Effects of Training on the Development of the Ability to Control Variables." Journal of Research in Science Teaching, 1973,10(3): 189-200.

Case, R. "Structures and Strictures: Some Functional Limitations on the Course of Cognitive Growth." Cognitive Psychology, 1974, 6: 544-573.

Case, R. "Gearing the Demands of Instruction to the Developmental Capacities of the Learner." Review of Educational Research, 1975: 45, 59-87.

Inhelder, B. and Piaget, J. The Growth of Logical Thinking From Childhood to Adolescence. New York: Basic Books, 1958.

Pascual-Leone, J. "A Mathematical Model for the Transition Rule in Piaget's Developmental Stages." Acta Psychologica, 1970, 32: 301-345.

Strawitz, B. Cognitive Style and the Acquisition and Transfer of the Ability to Control Variables. Paper presented at the meeting of the National Association for Research in Science Teaching, Boston, April, 1980.

Witkin, H. A., Oltman, P.K., Raskin, E., and Karp, S.A. A Manual for the Embedded Figures Tests. Palo Alto: Consulting Psychologists Press, 1971.

Wollman, W. "Controlling Variables: A Neo-Piagetian Development Sequence." Science Education, 1977, 61(3): 385-391.

Session E-4

AN ANALYSIS OF THE RANGE OF 2B AND 3A RESPONSES TO THREE INHELDER TASKS

Walter A. Farmer
State University of New York
at Albany
Albany, New York 12222

Students enrolled in ninth and tenth grade science and mathematics classes were the subjects selected for this investigation. The selection procedures employed were designed to insure a broad sampling across type of school and academic track. Responses to three of the original Inhelder tasks (Chemical Combinations, Flexible Rods, and Shadows) provided the data base. Researchers trained in administering these interview tasks conducted the testing and classification of subjects. Three of the same interviewers then analyzed 3A responses in order to (1) identify the range of reasoning patterns between and within substages 2B and 3A; (2) provide a data base of the diverse reasoning patterns employed by these subjects; (3) categorize these reasoning patterns into bands within substages; and (4) formulate hypotheses to guide further experimentation in this area of concern.

GENERAL SESSION II

PRESIDENT'S ADDRESS

THE POWER OF PURPOSE

John W. Renner
University of Oklahoma
Norman, Oklahoma 73019

Session F-1

AN ERROR ANALYSIS OF RESPONSES TO A TEST OF PROPOSTIONAL LOGIC

Michael D. Piburn
Morris A. Enyeart
Rutgers University
New Brunswick, New Jersey 08903

The main premise of Piaget's theory of Logical Reasoning is that there are correspondences between the structures of thought and those of formal logic (Piaget, 1957). This contention has been denied by Ennis (1975), who argues that Piaget's propositional logic is incorrect, and that his "...claim that children 11-12 and under cannot handle propositional logic is either untestable or false..."

This is an analysis of the errors made by a sample of 275 subjects on the Propositional Logic Test (PLT), a sixteen item test containing four items each of conjunction, disjunction, material equivalence, and material implication. The subjects were drawn from intact science classes ranging in grade from seven to twelve. The PLT conforms as closely as possible to the structure of the sixteen binary operations, which Piaget uses as a model, and thus seems an appropriate instrument for testing the rival hypotheses of Piaget and Ennis.

Since the PLT contains four items each of four operations, an ideal answer by any group would show 25% of the responses of each of the four categories of the PLT. Any other pattern must be interpreted as a failure to use correct logical interpretations.

Error analysis indicates that 97% of the responses to the PLT by this sample involve 8 of the 16 possible truth tables. The most commonly used operation is the conjunction. Between 50 and 60% of the answers given from grade 7 and 8 students are in this category. By the ninth grade, use of the conjuction interpretation drops to 25-30%, and use of the inclusive disjunction increases to the same level. However, the anticipated increase in the use of conditional truth tables (material equivalence and material implication) does not occur until the 11th grade.

These results appear to refute the position taken by Ennis (1975), and support the alternative suggested by Piaget. Younger subjects are unable to understand the logic of the conditional, and substitute (and) as a logical connective. The transition from this form of reasoning to that of the conditional seems to occur between the eighth and eleventh grades.

This interval of transition is most exciting to science teachers, since it suggests a time during which subjects have the competence to use advanced logical reasoning, but are not yet able to successfully perform on standard measures. It is during this period of the late junior high school and early high school that an intervention to promote logical reasoning ability might be most successful.

REFERENCES

Piaget, J., Logic and Psychology; New York: Basic Books (1957).

Ennis, R. H. "Children's ability to Handle Piaget's Propositional Logic: A Conceptual Critique." Review of Educational Research, 1975, 45: 1-41.

Session F-1

THE DEVELOPMENT OF THE ABILITY TO USE PROPOSITIONAL OPERATORS

William Martin
Walter Lockwood
Rutgers University
New Brunswick, New Jersey 08903

Research on the logical reasoning abilities of children is divided into at least two camps. On the one hand, there are studies which suggest that children are able to reason hypothetically only when formal operations have been attained (Roberge and Paulus, 1971; Taplin, et al., 1974). On the other hand, some studies indicate that children are able to deal with hypothetical reasonings not limited to the concrete operations (Hill, 1960; O'Brien and Shapiro, 1968; Ennis, et al., 1969).

Additionally, of the studies which indicate that the acquisition of logical reasoning ability is developmental in nature, there are those which indicate that the use of propositional operators develops sequentially. It is thought that the ability to use the conjunctive (CJ) operator develops first, followed by the ability to use the biconditional (BIC) operator, and then finally the ability the use the conditional (CON) operator (Taplin, et al., 1974).

This study focused on the ability of students to use four propositional operators: (conjunctive, disjunctive, biconditional, and conditional) as measured by the Propositional Logic Test (PLT) (Enyeart, 1980). Each test item consisted of two simple verbal propositions related by an operator and followed by four instances presented in graphic form. Four variables, each with two attributes, were selected to represent the propositional statement. They were largeness/smallness, roundness/squareness, tailed/untailed, and striped/unstriped. Four statements were designed for each operator.

The subjects were 300 students in grades 7-12 from a public school system in New Jersey. All were enrolled in a science course. Approximately 50% in grades 10-12 were in the science/math track. The remaining students were in a language/social studies track. Based on previous trends, it is estimated that 90% of the students from this upper-middle class system will go on to college.

Most students are able to successfully do the conjunction items. Only a very few of the seventh-and eighth- grade students (less than 6%) are able to do either the BIC or CON items. By ninth-grade, the percentage of students successful on these items is doubled. Increases in the number of students who are successful on the same BIC and CON items are made in the eleventh-grade. Of the twelfth-grade subjects, 42% were able to do the BIC and CON items.

This study also indicated that abilities to use the biconditional and conditional operators are closely related. Students able to do the CON were also able to do the BIC, and the converse was also true.

Results similar to those reported here were produced in a pilot study of 100 students. An added finding, not tested for in this study of 300 subjects, indicated that students who were enrolled in science/math or had a preference toward science/math were, at the seventh-grade level, similar in their abilities to use the logical operators. By the twelfth-grade however the science/math group outperformed the non-science/math group on the PTL.

It appears from these results that the ability to use four propositional operators is developmental. Additionally, the development of abilities to use the BIC and CON operators is closely related. There is also an indication that students with a preference toward science/math are more able to use the operators by the time they get to the twelfth-grade.

REFERENCES

Ennis, R. H., Finkelstein, M., Smith, E., and Wilson, N. "Conditional Logic and Children." Ithacca, New York: Cornell University. Cornell Critical Thinking Readiness Project, Phase II-C, Final Report, 1969.

Enyeart, Morris A. "Relationships Among Propositional Logic, Analogical Reasoning, and Piagetian Level." Unpublished doctoral dissertation, Rutgers University, 1980.

Hill, S. A. "A Study of Logical Abilities of Children." Unpublished doctoral dissertation, Rutgers University, 1960.

O'Brien, T. C., and Shapiro, B. J. "The Development of Logical Thinking in Children." American Education Research Journal, 1968. 5: 531-542.

Roberge, J., and Paulus, D. "Developmental Patterns for Children's Class and Conditional Reasoning Abilities." Developmental Psychology, 1971, 4: 191-200

Taplin, J., Staudenmayer, H., and Taddonio, J. "Developmental Changes in Conditional Reasoning: Linguistic or Logical?" Journal of Experimental Child Psychology, 1974, 17: 360-373.

Session F-1

LOGICAL OPERATIONS AND ACHIEVEMENT IN COMMUNITY COLLEGE STUDENTS

Walter Rothaug
George J. Pallrand
David Van Harlingen
Rutgers University
New Brunswick, New Jersey 08903

A Propositional Logic Test (PLT) was administered to a sample of 318 suburban community college students in various chemistry and mathematics classes and the results analyzed and correlated with achievement as measured by final letter grade. The results indicated little overall difference between the various classes on the PLT and, when final grade was included, scores on the PLT correlated (.4 to .6) significantly with final grade in chemistry courses but not in mathematics classes.

For further analysis, the statements on the PLT were subdivided into the four categories of propositional logic, conjunction (and), disjunction (or), conditional (if...then), and biconditional (two way if...then). An analysis of the conjunction responses indicated 77% answered these items correctly and there was no consistent pattern to the errors. When significant correlations between parts of the PTL and final grade were observed, they usually occurred in the disjunction, conditional, and biconditional parts and not on the conjunction. On the disjunction statements, only 36% responded correctly, while 11% answered as if it were a conjunction. On the conditional statements only 12% responded correctly, 51% responded as if the statement were a conjunction, and 16% responded in a manner which affirmed or disaffirmed the statement on the basis of the first part regardless of the second part. Almost identical results were observed with the biconditional statements.

The error patterns on the conditional and biconditional statements merit additional analysis and comment. The biconditional error patterns and percentages are very similar to the conditional, so only the conditional cases will be discussed in this abstract. The errors fall into two distinct patterns. The first, made by 51% of the respondents on the conditional statements, was to answer as if the statements were a conjunction. This sounds worse than it probably is, as this response is largely caused by the failure to recognize that the cases which are not addressed by the statement are classified as true if correct conditional reasoning is applied. Those in this error pattern incorrectly classify these cases as false. The other cases which are addressed by the statement are correctly classified when conditional reasoning is applied to them. The response pattern now though is identical to that generated if the statement were a conjunction. Subjects responding in this way are probably not completely lacking in conditional reasoning ability, just that it is not fully developed. Nevertheless, the number of nonaddressed instances correctly classified usually correlates significantly with achievement in chemistry courses.

The second error pattern exhibited by 16% of the subjects to the conditional statements, is a rather remarkable one. The conditional statement itself seems to impose an order on the object rather than the object itself existing independently. For instance, to the conditional statement "if large than round" a large square is classified as allowed by this rule because it is large. In clinical interviews, which were conducted with a number of subjects as a follow up to the PLT, subjects in this error pattern would hold up a large square and assert that it was round because of the statement "if large than round." These subjects seemed unable to recognize that a large square contradicted the statement. We ourselves do not fully understand the consequences of such a reasoning pattern but can report that it is widespread and persistent, and that students who reason in this way have serious difficulty in achieving high grades in science courses at the community college.

Session F-1

THE GROWTH OF PROPOSITIONAL LOGIC ABILITY DURING THE JUNIOR HIGH SCHOOL YEARS

Morris A. Enyeart
Michael D. Piburn
Rutgers University
New Brunswick, New Jersey 08903

The development of logical reasoning abilities is a goal that is common to many secondary science curricula. Yet, studies in this area continue to suggest there is little or no improvement in students' abilities to correctly solve problems requiring certain logical processes (Ennis, 1975; Lawson, Karplus, and Adi, 1978). From this evidence we must conclude that either our science curricula are failing to achieve one of their major goals or that the studies have failed in some way to uncover that developmental process.

The current study assumed that the latter condition was the case since we noted that prior studies searched only for the age at which subjects correctly solve problems of propositional logic. Correctly solving a problem is an indication of a developed ability; it is not an indicator of a developing ability. The development of a mental ability begins long before an individual is consistently successful at tasks requiring that form of reasoning.

In light of the above discussion, this study sought to answer the following questions.

1. When do children begin to use, correctly or incorrectly, the reasoning processes associated with propositional logic?
2. Is the appearance of this ability the result of a gradual process or does it appear suddenly at a specific age?
3. If the acquisition of propositional logic ability is a gradual process, does the ability to interpret different logical operators occur simultaneously?

Design and Sample

This cross-sectional study used a post-test-only with no control group design. The population from which the sample was drawn consisted of 750 junior high school students who had been randomly assigned by computer to thirty science classes. Our sample, obtained by randomly selecting two of the ten classes at each grade level, contained 51 seventh; 45 eighth; and 33 ninth-graders.

Instruments and Scoring

Two instruments were used to assess the ability to apply the reasoning inherent in propositional logic. The group administered Propositional Logic

Test is a 16-item test of a subject's ability to identify nonverbal examples of statements containing the most commonly used propositional logic operators. Reliability and validity are reported in Enyeart, Baker, and VanHarlingen (1980).

The quasi-clinically administered Turtles task is a modification of Wason's four-card task. Validity and reliability are reported in Bady (1979).

In addition to indicating when a subject was successfully interpreting a logical operator, the scoring protocol also pinpointed the source of the error when the subject was incorrect.

Results

1. The strategy selected to test the Turtles hypothesis was unrelated to interpretation of the logical operator.
2. There was no increase with age in the number of subjects correctly interpreting conditional operators.
3. Seventh-graders most often interpret conditional statements as conjunctions.
4. By ninth-grade, subjects are attempting to use conditional reasoning significantly more often than seventh- or eighth- graders but they are using it incorrectly.

Discussion

By the time children enter the junior high school they have begun to use some of the processes associated with propositional logic, namely conjunctive and disjunctive reasoning. During the time they are in junior high school they begin to recognize the inadequacy of these forms of reasoning in certain situations. This recognition leads the student to more frequently attempt to apply conditional reasoning at the appropriate time. However, the fact that the increase in the frequency of attempts at conditional reasoning is not mirrored by a similar increase in correct applications suggests these reasoning processes are still developing.

REFERENCES

Bady, R. J. "Students' Understanding of the Logic of Hypothesis Testing." Journal of Research in Science Teaching." 1979, 16: 61-66.

Ennis, R. "Children's Ability to Handle Piaget's Propositional Logic: A Conceptual Critique." Review of Educational Research, 1975, 45: 1-41.

Enyeart, M., Baker, D., and Van Harlingen, D. "The Correlation of Inductive and Deductive Logical Reasoning to College Physics Achievement." Journal of Research in Science Teaching, 1980, 17: 263-267.

Lawson, A., Karplus, R., and Adi, H. "The Acquisition of Propositional Logic and Formal Operational Schemata During the Secondary School Years." Journal of Research in Science Teaching, 1978, 15: 465-478.

Session F-2

USING QUESTIONS TO FOCUS STUDENTS' ATTENTION ON NON-PROSE SCIENCE MATERIALS

William G. Holliday
Garth D. Benson
University of Calgary
Calgary, Alberta Canada T2N 1N4

Lucas and McConkie (1980), Richards (1979), and Wilson and Koran (1976) identified printed study questions as one of the most successful ways of focusing students' attention on selective portions of textbook materials resulting in achievement facilitaiton or inhibition. In this regard, Holliday (1980, in press) and Wittrock and Lumsdaine (1977) recommended using the selective attention model as a source of hypotheses. The purpose of the present study was to utilize this model to investigate the learning effects of different questioning strategies under four experimental conditions using a non-prose medium (science textbook chart) containing information of varying established difficulty. McConkie (1977) suggested that recent research in "Learning From Text(s)" has been dominated by researchers manipulating students' attention (using study questions) with the goal of producing more effective texts and study aids for student use. He recommended that future research examine a variety of learning materials by more carefully (relative to reported research) defining operationally the relationships among content components, study and post-test questions, and instructional directions administered to students.

A 14-row, 4 column chart describing 14 vitamins was used to present four characteristics as established in pre-experimental study (columns 1-2 describing "easy-to-learn" names and food sources and columns 3-4 describing more "difficult-to-learn" abundance and deficiency symptoms). Questions derived from the chart (one question from each row) were paraphrased and randomly assigned in a counter balanced fashion to sub-groups of students within each group. Question placement and additional controls (e.g., practice performing instructional tasks before experiment) also were used, as suggested by Holliday and Partridge (1979) and Richards (1979).

A sample of 299 high school biology students enrolled in two high schools was randomly assigned to four experimental conditions (independent variable: instructional directions administered to students), and then within each condition randomly assigned to five treatment-control subgroups (independent variable: focusing attention on varied chart columns using questions). Instructional directions were varied among the following conditions: (1) a control; (2) students permitted to inspect post-test; (3) the importance of study questions was emphasized; and (4) a combination of treatments 2 and 3, as recommended by McConkie (1977). Focusing attention was varied among subgroups using a: (1) placebo control; (2) chart and no questions; (3) chart and column 1-2 questions; (4) chart and column 3-4 questions; and (5) chart and column 1-2-3-4 questions. Subsequently, students were administered a cued-achievement post-test corresponding to learned information in columns 1-2, columns 3-4, and columns 1-2-3-4.

As predicted (using Newman-Keuls), significant differences ($p \leq .05$) generally supported the major hypotheses regarding learning of such information. First, 47-48 subgroup cells outperformed the control. Second, the "easy" and "difficult" dichotomy was clearly established. Third, students who were provided a chart with no questions and who were permitted to inspect the post-test outperformed students in the same treatment who were not permitted to inspect the post-test. Fourth, students who were provided column 1-2 or 3-4 questions learned more of the questioned chart columns than the nonquestioned chart columns. Fifth, students who were provided column 1-2-3-4 questions were not differentially affected by the four classroom conditions and did not outperform the no-question treatment.

In conclusion, students' attention can be selectively focused with facilitory results on portions of a chart only under limited non-interference conditions, as evidenced by the differential response patterns. These nonprose findings are consistent with more recent prose studies, according to Holliday (1980) and McConkie (1977).

REFERENCES

Holliday, W. G. "Overprompting Science Students Using Adjunct Study Questions." A paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Boston, April, 1980.

Holliday, W. G. "Selective Attentional Effects of Textbook Study Questions in Student Learning in Sciences." Journal of Research in Science Teaching, 1980, (in press).

Holliday, W. G, and Partridge, Louise A. "Differential Sequencing Effects of Test Items on Children." Journal of Research in Science Teaching, 1979, 16:407-12.

Lucas, P. A. and McConkie, G. W. "The Definition of Test Items: A Descriptive Approach." American Educational Research Journal, 1980, 17: 133-140

McConkie, G. W. "Learning From Texts." In L. S. Shulman (Ed.), Review of Research in Education, Itasca, Ill.: F. E. Peacock Publishers, 1977.

Richards, J. P. "Adjunct Postquestions in Text: A Critical Review of Methods and Processes." Review of Educational Research, 1979, 49: 181-196.

Wilson, J. J. and Koran, J. J., Jr. "Review of Research on Mathemagenic Behavior: Implications for Teaching and Learning Science." Science Education, 1976, 60: 391-400

Wittrock, M.C. and Lumsdaine, A. A. "Instructional Psychology." In M. R. Rosenzweig and L. W. Porter (Eds.), Annual Review of Psychology, Vol 28, Palo Alto, California: Annual Review Inc., 1977.

Session F-2

THE RELATIONSHIP OF PROSE STATEMENTS ASSESSING THE ENERGY CRISIS AND THE COGNITION OF FIGURAL PERCEPTION TRANSFORMATIONS

David P. Kielbowick
University of Pittsburgh
Pittsburgh, Pennsylvania 15260

The purpose of this study was to investigate the relationship between the kinds of words used in describing an abstract social situation and performance on a set of figural transformations for twelve to fourteen year old junior high school students.

The students were measured in their ability to observe a diagram with lines on it, the lines representing where folds could be made. They were asked to imagine these diagrams were being folded and to chose which of the four photographs of three-dimensional figures the diagrams would most closely resemble if the diagrams were actually folded on the lines provided.

Prose statements on an abstract social situation, the Energy Crisis of 1979, were used to determine if the total number of words used, total number of different words used, and the frequency of words used could function as a predictor of the student's cognition of the figural transformations.

The frequency of certain words used to describe the energy crisis were found to be related to a student's ability to discriminate among the line diagrams and choosing the photographed three-dimensional figures, which most closely approximated the actual folded diagrams.

Session F-2

RESEARCH APPROACHES FOR ANALYZING FREE PROSE DATA EMBEDDED IN CURRICULUM

David D. Carbonara
University of Pittsburgh
Pittsburgh, Pennsylvania 15260

It can be debated that forced-choice opinion polls do not adequately measure the person's attitude about a particular topic. But, with the aid of a high-speed computer, one can properly measure a students's attitude using the unbiased method of free-prose passages.

This paper describes the methods on how to collect, analyze and interpret free-prose passages. The SNOBOL-4 "word count" program supplies a frequency count of the words, while the BMDP modules perform the cluster and correlation analyses.

Results indicated that even though the two subgroups of mental operations and prose words are separate sub-clusters, it can be shown that these sub-clusters may be thought of as one, due to the following facts: (1) the sub-clusters are combined at a distance of 0.63; and (2) this distance is significant at $p \leq 0.05$. Thus, a successful, statistical attempt to analyze free-prose passages has been accomplished. This paper has shown that prose can be analyzed using computer applications and that these results can be further analyzed through cluster analytic methods. The implications for science education lie in the fact that terms specific to curricula may now be analyzed as obtained from the free-prose passage. This would greatly aid the curriculum developer. Now, a quantitative interpretation of students' attitudes on a specific curriculum topic may be used to design various pedagogical materials to guide the student from his/her current position to a desired position within the curriculum.

Session F-3

WHO TRANSLATES RESEARCH INTO PRACTICE?

A LOOK AT THE PERSONALITY PROFILES OF SCIENCE EDUCATION ENGINEERS

John E. Lutz
Rochester Institute of Technology
Rochester, New York 14623

Applying research to solving school problems and determining essential elements to translate R and D products into practice have been identified as priorities for research by the National Association for Research in Science Teaching. No work to date, however, has reported on the characteristics of those successfully engaged in research applications in science education.

This study was designed to investigate the personality factors that could characterize successful performance in the educational linker role of establishing linkages between R and D and the science classroom. Results supported the hypothesized similarity of the linker personality to those of engineers, school superintendents, and business executives. In addition, the linker personality was found to be different, as hypothesized, from that of researchers, but not as different from teachers as expected. It was concluded that there is a distinctive personality for the emergent educational linker role and was suggested that expression of this personality guides the successful accomplishment of the linking process. Finally, linker ability and effectiveness were related to the personality assessments, and educational policy issues were addressed.

Session F-3

PROJECTIVE SPATIAL REASONINC OF UNDERGRADUATE COLLEGE STUDENTS

Linda J. Kelsey
West Virgina University
Morgantown, West Virgina 26506

Piaget has outlined an extensive theoretical framework for the development of spatial reasoning. This study was designed to assess the spatial reasoning abilities of college students and to investigate the relationship between two of Piaget's projective groupings of operations and their use in solving problems involving phases of the moon. Phases of the moon is a topic taught in many science courses at all levels, and typical textbook presentations seem to assume that students have developed the concrete operational structures necessary to do the required spatial reasoning.

One hundred subjects enrolled in a one-semester introductory astronomy course were given personal task interviews of six tasks. They were: (1) Mountains, coordination of perspectives; (2) Mountains and Stars, coordination of outside-in and inside-out points of view; (3) Tilt of Cone and Rings, coordination of views of an object undergoing plane rotation; (4) Person-Centered Phases of the Moon, dealing with phases from the observer's own viewpoint; (5) Earth-Centered Model Phases of the Moon, dealing with phases from the viewpoint of an Earth-bound observer; and (6) Top-On Drawing Phases of the Moon, using a top view of the Earth-Sun-Moon system similar to those used in most textbooks.

A modified scalogram analysis indicated that five of the tasks scaled in difficulty. When these data were combined with those of the sixth task the following order from the least to most difficult was obtained: Mountains (IGP_4), Tilt of Cone and Rings (IGP_8), Mountains and Stars, Person-Centered Phases, Earth-Centered Model Phases, and Top-On Drawing Phases. It was concluded that the mental structures for IGP_4 and IGP_8 were necessary but not sufficient for dealing with problems about phases of the moon.

Chi-square tests were used to test for gender-related differences in performance on task subscores, and no significant difference was found for any task. Chi-square tests showed no significant differences in task performance for any task between science oriented students (who had completed 20 hours or more of math and science courses) and non-science oriented students.

Several educational implications can be drawn from this research. The majority of students enrolled in the general education astronomy courses could not use the mental structures for projective space. Seventy-three

percent performed at the highest level on the Mountains task, while only 35 percent could successfully complete the Tilt of the Cone and Ring task. Passing proportions on the Phase of the Moon tasks were between 30 percent and 12 percent, even after the material had been presented in class. The lack of difference between science and non-science oriented students questions the spatial reasoning abilities of students in other science courses, including those above the introductory level. Many content areas of physics, chemistry, astronomy, and geology would also appear to require spatial reasoning. The assumption that college students have and can use the necessary mental structures is not justified. As a result, many of the teaching materials and presentations now used at all classroom levels may be inappropriate.

Session F-3

THE EFFECTS OF SELECTED STUDENT CHARACTERISTICS AND COLLEGE LEARNING ENVIRONMENT ON SCIENCE PROCESS SKILLS AND INFORMATION AQUISITION

John E. Penick
Gerry Haukoos
The University of Iowa
Iowa City, Iowa 52242

This investigation was designed to study the effect of two specific classroom climates on learning of science process skills in college level science classes. It also identified certain student characteristics which promoted or inhibited the acquisition of skills in each of the classroom climates.

The two classroom climates established were designed as discovery classroom climate (DCC) and nondiscovery classroom climate (NDCC). The term discovery denotes the degree of freedom the teacher established in classroom interactions, both verbal and nonverbal. Verbal interactions were monitored with the Science Laboratory Interaction Categories (Shymansky, et al., 1979).

These data indicate that students in the two classroom climates achieved equally well on learning of biological content of the course, but students in the discovery classroom climate achieved significantly higher scores in science process skills as measured by the Welch Science Process Inventory. Of the 15 personality characteristics measured by the Edwards Personal Preference Schedule, there were varying degrees of correlation with improvement of science process skills and learning of the course content.

This study, conducted in a large, suburban community college, offers some useful information to the person who has educational goals beyond (but including) the learning of science information and concepts. This study indicates you may well be able to have your cake and eat it too. Students in the less directive discovery climate learned as much content as the control class-they have lost nothing of what is traditionally sought in a college class. In addition, the discovery climate facilitated the development of science process skills which were significantly better than the control class.

REFERENCE

Shymansky, J. A., Pennick, J. E., and Kyle, W. C., Jr. "How do Science Laboratory Assistants Teach?" Journal of College Science Teaching, 1979, 9 (1): 24-27.

Session F-4

OBJECTIVE AND CONTINUOUS ASSESSMENT OF STUDENT PERFORMANCE IN THE PHYSICS LABORATORY

Uri Ganiel
Avi Hofstein
The Weizmann Institute of Science
Rehovot, Israel

Rationale

Laboratory work plays a central role in most modern high school physics curricula. However, whereas well developed methods for testing and assessment of theoretical work have existed for many years, assessment of student performance in the laboratory has not received sufficient attention (Grobman, 1970). Several research studies (Kelly and Lister, 1969; Tamir, 1972 and Ben-Zvi et al., 1977) have shown that laboratory work in science teaching is not only a unique mode of instruction but that it also requires a unique mode of evaluation.

In a preliminary survey conducted amongst physics teachers in Israel it was found that most of them emphasize mainly cognitive skills and neglect the more practical laboratory skills. This is true for their teaching and consequently also for their assessment, even though the work in the laboratory is aimed at developing both types of skill.

The present study was conducted in order to develop and validate an instrument for objective and continous assessment of student performances in the physics laboratory.

Methodology

In this study, 24 teachers viewed video-tape recordings of two students performing experiments and were then asked to assess the student's performance. It was found that each teacher assessed some of the skills and neglected others, according to his personal preference (subjective assessment).

An instrument for continuous, objective assessment of student performance in the laboratory was developed. This instrument was designed to assess student performance in the laboratory based on a list of specific criteria.

After some initial training, the teachers practiced the use of this instrument in their own classrooms for about four months. They then used it to assess the performance of the same two students. Finally, an attitude questionnaire was administered to assess teachers' opinions with regard to the use of the instrument.

Results and Discussion

The comparison between the results of the two modes of assessment revealed a considerable improvement. Using the instrument, the teachers considered all the skills. Further, much greater uniformity was achieved, i.e., reduced spread in the teachers' assessment of a given experiment for a given student, and consistency in the assessment made by a given teacher over a number of experiments. More specifically it was found that the correlation (Pearson r) between the scores on the two experiments given by the teacher subjectively was 0.36 ($p \leq 0.11$) whereas the correlation between the scores given objectively (using the assessment instrument) was 0.70 ($p \leq 0.004$).

It was also found that teachers demonstrated a highly positive attitude toward the use of such an instrument, both for continuous student assessment in physics instruction and also in the final (matriculation) examinations. We believe that an instrument of this kind will improve not only assessments, but also the contribution of laboratory work to physics teaching.

REFERENCES

Ben-Zvi, R., Hofstein, A., Samuel, D., and Kempa, R. F. "Modes of Instruction in High School Chemistry." Journal of Research in Science Teaching, 1977, 14: 433-439.

Grobman, H. Developmental Curriculum Projects: Decision Points and Processes. Itasea, Illinois, Peacock Publishers, Inc., 1970.

Kelley, P. J. and Lister, R. E. "Assessing Practical Abilities in Nuffield A-Level Biology." In J. F. Egelston and J. F. Kerr (Eds.) Studies in Assessment. London: English Universities Press Ltd., 1969.

Tamir, P. "The Practical Mode - A Distinct Mode of Performance in Biology." Journal of Biological Education, 1972, 6: 175-182.

Session F-4

A DESCRIPTIVE INSTRUMENT FOR USE IN INVESTIGATING SCIENCE LABORATORIES

Michael R. Abraham
University of Oklahoma
Norman, Oklahoma 73019

The purpose of this paper is to introduce a Q-sort type instrument which is useful for obtaining descriptive information about teaching methods and curriculum materials used in the science laboratory. This instrument, The Laboratory Program Variables Inventory (LPVI), was used in a series of experiments investigating laboratory formats used in college general chemistry courses. Three possible formats were investigated: (1) verification laboratories; (2) guided inquiry laboratories; and (3) open/guided inquiry laboratories. Using several data analysis techniques, LPVI data were used to operationally define the three formats and identify specific criteria for discriminating among them. The use of the Q-sort, in general, and the LPVI specifically, might fulfill a number of evaluation needs in science education including: (1) developing an operational definition of constructs (i.e., inquiry); (2) diagnosing problems in curriculum development or implementation; (3) rationalizing differences in treatment groups in educational experiments; and (4) monitoring the effect of teacher education efforts.

Session F-4

A LABORATORY STUDY OF PHYSICS TEACHING IN THE EGYPTIAN GENERAL HIGH SCHOOL IN LIGHT OF RECENT INTERNATIONAL TRENDS

Ahmed Khalil Mohamed Hassan
Al-Azhar University
Madinet Masr-Cairo Egypt

Objectives

The purpose of this study was to conduct a systematic survey of trends in the teaching of physics at the high school level, to develop new units, and to evaluate selected units developed for the Arabic Pilot Project for Teaching Physics. Within the framework of this purpose, the investigation was intended to answer the following questions:

1. What are the new international trends in developing and teaching physics at the high school level?

2. In the light of these trends, what are the major principles of the Arabic Pilot Project for Teaching Physics in High Schools in the Arab Countries?

3. What are the advantages, if any, experienced by students who are taught physics by way of the Arabic Pilot Project as compared to students taught physics by way of a previously developed (traditional) physics program?

Procedures

The first step in the investigation involved an examination of international and regional trends in the development of "new" physics curricula during the second half of the current century (since 1957). From this examination, the most important trends were identified and incorporated into the Arabic Pilot Project for Teaching Physics in High Schools in the Arab Countries. One of these units, "Motion" was evaluated in terms of the extent to which it met specific objectives associated with the teaching of physics at the high school level. From 97,578 tenth-grade students in Egypt, 1190 students were randomly identified and randomly assigned to experimental and control groups -580 students/group. (The two groups were found not to be significantly different in age and sex). The physics teacher in each school taught both experimental and control groups.

Control treatment consisted of teaching selected units from the traditional physics course and the experimental treatment consisted of teaching physics from a unit on "Motion" which had been developed for the Arabic Pilot Project. Utilizing objective achievement tests for which reliability and validity had been established, students in control and experimental

groups were tested and data were analyzed through appropriate statistical instruments using programs and facilities of the Computing Center of the AIN-SHAMS University in Cairo. The following hypotheses were tested:

1. There are no significant differences between control and experimental groups in knowledge, comprehension, and application of knowledge as measured by objective examination associated with the Arabic Pilot Project-unit on "Motion".

2. There are no significant differences between control and experimental groups in specific skills measured by objective examination associated with the traditional high school physics curriculum.

3. There are no significant differences between male control subjects and male experimental subjects in terms of knowledge, comprehension, and application of knowledge as measured by objective examination associated with the Arabic Pilot Project-unit on "Motion".

4. There are no significant differences between male control subjects and male experimental subjects in terms of specific skills measured by objective examination associated with the traditional physics curriculum.

5. There are no significant differences between female control subjects and female experimental subjects in terms of knowledge as measured by objective examination associated with the Arabic Pilot Project-unit on "Motion".

6. There are no significant differences between female control subjects and female experimental subjects in terms of specific skills measured by objective examination associated with the traditional high school physics curriculum.

Results and Conclusion

Each of the above null hypotheses were rejected ($p \leq .01$) and the advantage was in each case in favor of the experimental group. From these findings it can be concluded that the "Motion" unit from the Arabic Pilot was more effective than comparable units from the previously-developed (traditional) curriculum. Students as a whole, male students taken separately, and female subjects taken separately achieved higher levels of knowledge, comprehension, and application of knowledge associated with the new (experimental) curriculum if taught physics by way of the experimental curriculum. Furthermore, these same groupings of students achieved higher levels of achievement on the objectives of the old (traditional) curriculum if taught physics by way of the new (experimental) curriculum.

It appears that it is feasible and desirable to develop new curricula in high school physics for the general high schools of Egypt by analyzing international and regional trends in physics curricula for this level and by applying these trends to curriculum development of the Arabic Pilot Project.

Session F-5

TREND ANALYSIS USING MICROCOMPUTERS

Carl F. Berger
The University of Michigan
Ann Arbor, Michigan 48109

This session will demonstrate how microcomputers can be used to analyze trends using multiple regression, polynomial regression, and exponential regression to fit models to data. Various techniques to display information will be presented. Hands-on demonstrations will be carried out using microcomputers. Program listings and documentation for Pet and Apple microcomputers will be made available to workshop participants.

Session G-1

THE INFLUENCE OF VOLUNTARY DIAGNOSTIC TESTING ON THE SCIENCE ACHIEVEMENT OF UNIVERSITY STUDENTS

Wenda J. Adams
University of North Carolina,
at Chapel Hill
Chapel Hill, North Carolina 27514

Russell H. Yeany
Edwin A. Helseth
University of Georgia
Athens, Georgia 30602

The purpose of this study was to investigate the effectiveness of a diagnostic/prescriptive system for increasing the science achievement of university students, and to examine the relationship between selected student characteristics and participation in the voluntary diagnosis. The following research questions provided the focus for this study:

1. Can achievement be predicted on the basis of participation in voluntary diagnostic/prescriptive testing when variables such as academic aptitude, achievement motivation, and locus of control are controlled?

2. What relationships exist between locus of control, achievement motivation, or academic aptitude and the student's voluntary use of diagnostic/prescriptive tests?

3. Is continued participation in voluntary diagnostic/prescriptive testing a function of the student's level of success on course examinations and/or the number of D-P tests taken?

Subjects of the study were 173 introductory biology students at North Carolina State University during fall semester 1979. The basic design can be diagrammed in Campbell and Stanley (1966) notation as follows:

$$O_1 \quad O_2 \quad O_3 \quad X_1 \quad O_4 \quad X_2 \quad O_5 \quad X_3 \quad O_6 \quad O_7$$

where:

O_1 = Locus of control assessment;

O_2 = Achievement motivational assessment;

O_3 = SAT scores;

X_1 = Diagnostic/prescriptive tests voluntarily taken on first examination topics;

O_4 = First summative examination on basic and organic chemistry, and cellular structure, respiration, and division;

X_2 = Diagnostic/prescriptive tests voluntarily taken on second examination topics;

O_5 = Second summative examination on protein synthesis, meiosis, and genetics;

X_3 = Diagnostic/presciptive tests voluntarily taken on third examination topics;

O_6 = Third summative examination on biology of plants and animals; and

O_7 = Final summative examination.

Eleven diagnostic/prescriptive tests were offered on an optional basis in the Learning Center. Each test consisted of 20 multiple-choice questions designed to check the student's mastery of the concepts.

Science achievement was defined by the scores on multiple-choice examinations. Each examination consisted of 50 items, except for the final examination which contained 75 items.

All data were analyzed through general linear model and analysis of variance programs on SAS and SPSS computer packages.

The data indicated that the number of diagnostic/prescriptive tests voluntarily taken influenced achievement ($p \leq .01$) when other variables were controlled and was also the best single predictor of achievement. Results also showed that: (1) Students lacking either a strong internal or a strong external locus of control voluntarily took a greater number of diagnostic/prescriptive tests ($p \leq .07$); (2) there was no difference in the number of diagnostic/prescriptive tests voluntarily taken by students of varying levels in achievement motivation; and (3) the number of diagnostic/prescriptive tests that students of low academic aptitude volunteered to take was significantly greater than the number taken by students of middle or high aptitude ($p \leq .009$).

Another finding was that if students began participation in diagnostic/prescriptive testing they tended to continue if they were successful on the course examinations; but, they did not continue if they met failure. Students who never started taking the tests did not begin as a result of success or failure on their examinations. Students who took most of the tests continued taking them regardless of whether they succeeded or failed.

The above results indicate that a voluntary diagnostic testing program can significantly increase university science achievement. On the basis of these findings, the voluntary diagnostic/prescriptive system should be considered for implementation in science programs, and in addition, ways to broaden student participation should be researched.

REFERENCE

Campbell, D. and Stanley, J. Experimental and Quasi-experimental Designs for Research. Chicago: Rand-McNally, 1966.

Session G-1

THE INFLUENCE OF VOLUNTARY DIAGNOSTIC TESTING ON THE SCIENCE ACHIEVEMENT OF UNIVERSITY STUDENTS: A REPLICATED STUDY

Russell H. Yeany
Edwin A. Helseth
University of Georgia
Athens, Georgia 30602

Wenda J. Adams
University of North Carolina
at Chapel Hill
Chapel Hill, North Carolina 27514

The purpose of this study was to replicate a recent study conducted at North Carolina State University which investigated the effectiveness of a diagnostic/prescriptive system for increasing the science achievement of university students and examined the relationship between selected student characteristics and participation in voluntary diagnosis. The following research questions provided the focus of both the North Carolina study and the present study which was conducted at the University of Georgia:

1. Can achievement be influenced by voluntary participation in diagnostic/prescriptive testing when variables such as academic aptitude, achievement motivation, and locus of control and logical thinking ability are controlled?
2. Is there a relationship between locus of control, achievement motivation, academic aptitude or logical thinking ability and the student's voluntary use of diagnostic/prescriptive tests?
3. Is continued participation in voluntary diagnostic/prescriptive testing a function of the student's level of success on course examinations and/or the number of D-P tests taken?

Subjects of this study were 107 university students enrolled in an introductory level biology course at the University of Georgia during the summer quarter of 1980.

The basic design can be diagrammed in Campbell and Stanley (1966) notation as follows:

$$O_1 \quad O_2 \quad O_3 \quad O_4 \quad X_1 \quad O_5 \quad X_2 \quad O_6 \quad X_3 \quad O_7$$

where:

O_1 = Locus of control assessment;

O_2 = Achievement motivation assessment;

O_3 = SAT scores;

O_4 = Test of Logical Thinking;

X_1 = Diagnositc/prescriptive tests voluntarily taken on first examination topics;

O_5 = First summative examination on basic and organic chemistry, and cellular structure, and division;

X_2 = Diagnostic/prescriptive tests voluntarily taken on second examination topics;

O_6 = Second summative examination on protein synthesis and animal development;

X_3 = Diagnotic/prescriptive tests voluntarily taken on third examination topics;

O_7 = Third summative examination on Mendelian and modern genetics.

The diagnostic tests were offered on an optional basis in the Bioscience Learning Center each focusing on topics covered in the course. Each test consisted of twenty multiple-choice questions designed to check the student's achievement of the concepts.

Science achievement was defined by the scores on three multiple-choice examinations. Each examination consisted of forty items. Items had been pilot tested and were judged to be valid and reliable for the course objectives.

All data were analyzed through general linear model programs on the SAS computer package.

In relation to the first research question, the data indicated that the number of diagnostic/prescriptive tests taken influenced achievement on exams 1 and 2 and on total achievement when other variables were controlled.

In relation to the second research question, the data indicated that: (1) there was no difference in the number of tests taken voluntarily by students of varying achievement motivation and locus of control; (2) the number of diagnostic tests that students of a low verbal academic aptitude volunteered to take was significantly greater than the number taken by students of higher verbal ability; and, (3) the converse for quantitative ability.

In relation to the third research question, the data indicated that if students began participation in diagnostic/prescriptive testing they tended to continue if they were successful on the course examinations, but they did not continue if they met failure. Students who never started taking the tests did not begin as a result of success or failure on their examinations. Students who took most of the tests continued taking them regardless of whether they succeeded or failed.

The above results indicate that a voluntary diagnostic testing program can significantly increase university biology achievement. The same general achievement and D-P usage trends reported in the North Carolina study were also observed in this study. On the basis of the findings the voluntary

diagnostic/prescriptive system should be considered for implementation in science programs. In addition, ways to broaden student involvement should be investigated.

REFERENCE

Campbell, D. and Stanley, J. Experimental and Quasi-experimental Designs for Research. Chicago: Rand-McNally, 1966.

Session G-1

PREDICTING SCIENCE ACHIEVEMENT OF UNIVERSITY STUDENTS ON THE BASIS OF SELECTED ENTRY CHARACTERISTICS

Edwin A. Helseth
Russell H. Yeany
University of Georgia
Athens, Georgia 30602

Wenda J. Adams
University of North Carolina
at Chapel Hill
Chapel Hill, North Carolina 27514

Purpose

The purpose of this study was to examine the relationships between university students' entry characteristics and achievement in biological science. The variables which were judged most likely to be predictors of achievement because of the nature of the subject matter or instructional conditions were: (1) scholastic aptitude (quantitative and verbal); (2) level of cognitive development; (3) locus of control; (4) grade point average; (5) age; and (6) gender.

Data on the entry variables locus of control and logical thinking ability were collected through standardized tests. Age, SAT scores, gender and GPA were collected from computer stored records.

Data on all achievement variables were collected with multiple-choice objective referenced tests. Item and test analyses were used to establish reliabilities, and objective-item matching by judges was used to ensure content validity. A total of four achievement tests were administered.

Data were examined by using regression analysis and general linear model procedures with SAS computer programs. Student achievement on the four tests was identified as separate dependent variables while scholastic aptitude, LOC, cognitive development, gender, GPA, and age were independent variables.

The subjects in this study were 1000 plus university students enrolled in an introductory biology course at the University of Georgia; data were collected over three quarters during 1979-80.

On all the biology achievement measures, the SAT (quantitative) score was the single best predictor of achievement, while the second best predictor was level of cognitive development. The best four variable model for predicting success on the first test included cognitive development, SAT (quantitative and verbal), and GPA; on the second test, SAT verbal was replaced by age; on the third, SAT verbal was replaced by gender; and, on the fourth, age, gender, SAT (quantitative), and GPA comprised the model. SAT (quantitative) and GPA contributed to all the models, while cognitive development contributed to three of them. Larger models were generated and analyzed but contributed little to the predicted variance. Locus of control as measured in this study was not a significant predictor of biology achievement.

The improvement of postsecondary science instruction and the resultant learning outcomes require continual attention. More developmental and research efforts should be applied in this area. Some attention should also be given to ensure that students of varying entry skills and abilities are provided with means of improving these skills and abilities. There is a possibility that solving problems similar to those in a science unit could stimulate the development of these skills. Also, when the primary purpose of instruction is to aid the learning of a particular set of concepts or skills (e.g., genetics), pedagogical methods designed to help overcome deficient student entry skills (e.g., logical thinking) should be employed. In this case, less abstract and more concrete examples may be needed by some students.

Session G-2

THE ACQUISITION OF FORMAL REASONING ABILITY VIA A NEO-PIAGETIAN TREATMENT

William Lamb
Frederica Academy
Saint Simons Island, Georgia 31522

Marianne Betkouski
University of North Florida
Jacksonville, Florida 32216

One instructionally useful approach to the development of formal reasoning ability is based on Robbie Case's "neo-piagetian" approach to thinking processes. Using this approach, the authors designed instruction to teach students to control variables using problems involving from two to five variables in real-life classroom settings. The treatments considered the following steps:

1. Consider what is interfering with problem solutions;
2. Begin instruction with a context that is simple, familiar, and as easy to perceive as possible;
3. Design problems within the simplified context such that students can easily see they are missing the problem solution without having to be told by the teacher;
4. Insure that each student knows why his or her unsuccessful strategy is inadequate and why the appropriate strategy is better, usually by employing questioning probes first followed by explanation and modeling if the probes don't work;
5. Provide opportunities for practicing the appropriate strategy in a variety of situations;
6. Introduce new problem features one at a time until students are able to solve complex problems.

The subjects were high school students in southeast Georgia and college education majors in northeast Florida. Results show significant gains in ability to control variables among the high school group as measured on one of two tests of formal reasoning: Lawson's (1978) Classroom Test of Formal Operations or Tobin and Capie's (1979) Test of Logical Thinking. Although the college group "topped out" on the controlling variables section of the test, they showed significant gains in formal reasoning overall. The authors are continuing to refine the treatment and testing. Teachers interested in designing instruction patterned after Case are urged to use originality in constructing problem situations and in adapting materials to student needs.

REFERENCES

Case, R., "Intellectual Development and Instruction; A Neopiagetian View." in Lawson, A.E. (ed.), The Pyschology of Teaching for Thinking and Creativity, AETS Yearbook VII, Columbus, Ohio: ERIC/SMEAC (1980).

Lawson, A. E., "The Development and Validation of a Classroom Test of Formal Reasoning." Journal of Research in Science Teaching, 1978, 15, 11-24.

Tobin, K, and Capie, W., "The Development and Validation of a Pencil and Paper Test of Logical Thinking." unpublished paper, the University of Georgia at Athens, 1979.

Session G-2

TEACHING FORMAL REASONING IN A COLLEGE BIOLOGY COURSE FOR PRE-SERVICE TEACHERS

Anton E. Lawson
Arizona State University
Tempe, Arizona 85281

Objectives

The purpose of the present study was to assess the effect of a one semester college biology course on the development of student's ability to reason formally. The course was inquiry-based and included specific provisions for instruction of the following components of formal reasoning: the control of variables, proportional, correlational, probabilistic, and combinatorial reasoning. The following questions were addressed: (1) Can such inquiry-based instruction produce measurable gains in student's use of formal reasoning to solve novel problems? (2) To what extent does increased performance on problems involving trained reasoning patterns transfer to problems involving non-trained reasoning patterns? (3) To what extent is increased performance accompanied by an increase in general intelligence? and (4) What cognitive variables(general intelligence, level of intellectual development, or field dependence/field independence) best predict post-test performance?

Method

The subjects(Ss) were 5 males and 67 females (18.0 to 41.7 years $\bar{X}$ = 22.7 years; SD = 4.9 years). On the first day of class half of the Ss (Group 1) were pre-tested using the Lawson Test of Formal Reasoning (Lawson, 1978) while the other half (Group 2) were pre-tested using the Raven Standard Progressive Matrices Test (Raven, 1938). Later the Group Embedded Figures Test (Witkin, Oltman, Raskin, and Karp, 1971) was administered to all Ss. During the last week of class all Ss were post-tested using the Lawson and Raven Tests and a pencil-paper test of formal reasoning.

The general teaching strategy was to let Ss generate and carry out experiments in teams. Then compare results with other teams and reflect upon similarities and differences in results as a means of identifying mistakes or inadequacies in the procedures and therefore in reasoning. The correct reasoning was then introduced and named and Ss were directed to attempt the solution of novel problems using that reasoning.

Results

Of the Group 1 Ss, six (16.6%) were concrete operational on the pretest and none were on the post-test. Two concrete Ss dropped the course. Twenty-six Ss (72.2%) were classified as transitional on the pre-test. Eight (25%) were classified as such on the post-test. The number of formal Ss increased from 4 (11.1%) to 24 (75%).

Two Group 2 Ss (16.1%) were classified as concrete, ten (30.3%) were classified as transitional, and 21 (63.6%) were classified as formal on the post-test. The overall Group 2 mean score of 11.34 was slightly lower than the Group 1 mean of 12.41 suggesting that Group 1's taking the pre-test slightly improved their post-test performance.

Data indicated that nonspecific transfer of training did not occur. Overall gains in general intelligence also did not occur. Correlations between the three predictor variables: (1) performance on the Raven Test, (2) pre-test level of cognitive development, and (3) degree of field-dependance/field-independence and post-test level of cognitive development were .66, .53, and .15 respectively. The coefficients for the respective variables with the post-test pencil-paper items of formal reasoning were .70, .46, and .29.

Conclusions

For students of the kind enrolled in the present course, instruction must involve much more than the use of open-ended inquiry-oriented laboratory experiments if significant gains in formal reasoning are to be observed within a single semester. The primary implication is that instruction designed to enhance formal reasoning must acknowledge the limitations of the concrete and/or field dependent student. One should not run the risk of overwhelming those types of students at the outset with too little structure.

The finding that some field dependent-low intelligent students (who are perhaps habitual users of relatively little mental capacity) either dropped the course or were relatively resistant to instruction is important. Experience with these students suggests that, for most of them, jobs other than teaching science would be preferrable.

REFERENCES

Lawson, A. E. "The Development and Validation of a Classroom Test of Formal Reasoning." Journal of Research in Science Teaching, 1978, 15 (1): 11-24.

Raven, J. C. Progressive Matrices: A Perceptual Test of Intelligence, Sets A, B, C, D, and E. London: Lewis, 1938.

Witkin, H. A.; Oltman, P. K.; Raskin, E.; and Karp, S. A. A Manual for the Embedded Figures Tests, Palo Alto: Consulting Psychologists Press, 1971.

Session G-2

PREDICTING THE PIAGETIAN COGNITIVE LEVELS OF TEACHER EDUCATION STUDENTS AT THE PENNSYLVANIA STATE UNIVERSITY

Hassan H. Zeitoun
H. Seymour Fowler
The Pennsylvania State University
University Park, Pennsylvania 16802

This study was mainly concerned with the prediction of the Piagetian cognitive levels (the criterion variable) of teacher education students from a set of the following six predictor variables: (1) science achievement as measured by Sequential Test of Educational Progress (Science Form 1A); (2) sex; (3) high school grade point average; (4) verbal aptitude as measured by the verbal portion of the Scholastic Aptitude Test; (5) mathematical aptitude as measured by the mathematical portion of the Scholastic Aptitude Test; and (6) field independent-field dependent cognitive style as measured by the Group Embedded Figures Test. Piagetian levels were measured using the Burney Logical Reasoning Test.

The sample selected for this study consisted of 126 volunteers (60 males and 66 females) from the College of Education at The Pennsylvania State University during the Fall Term 1979 and Winter Term 1980. Two statistical techniques were utilized to treat the data: (1) Tukey jackknife for cross-validation and (2) stepwise multiple regression. The study's findings demonstrated that (1) the six predictor variables succeeded in predicting the Piagetian cognitive levels. They accounted for 58%, 53%, and 59% of these level's variance in the pooled male and female sample, male sample, and female sample respectively; (2) a subset of variables including science achievement, field independent-field dependent cognitive style and verbal aptitude was selected by the stepwise method to be included in the prediction equations of the male sample; and, (3) the predictive validities as calculated by the corrected cross-validation R-square (R^2_tC) of the prediction equations developed for the pooled male and female samples and the male sample and female sample were found to be 0.57, 0.54, and 0.55 respectively.

Session G-3

THE DETERMINATION OF THE SCIENTIFIC LITERACY OF THE STUDENTS IN TWELVE SPECIFIC COUNTIES IN GEORGIA

Constance T. McNeill
East Coweta High School
Senoia, Georgia 30276

David P. Butts
University of Georgia
Athens, Georgia 30602

Education for scientific literacy should be a cumulative experience lasting a lifetime and should provide individuals with the knowledge and skills for effective personal and family decision-making. The responsibility for preparing scientifically literate individuals rests with the schools. This is one of the major thrusts of schools in Georgia. However, few attempts have been made to assess the attainment of scientific literacy. The purposes of this study were (1) to assess the present level of scientific literacy of students in twelve public school systems in Georgia on an abbreviated form of the National Assessment of Educational Progress Science Test; (2) to compare the performance of these students on specific test items with the performance of equivalent-grade students used in the test standardization; and (3) to determine the relationship of certain demographic variables (gender, race, size of school system, and geographic location of school system) on the acquisition of scientific literacy.

Instruments based on the National Assessment of Educational Progress Science Tests were developed for use in Georgia. These were administered to the Georgia sample. Data were analyzed to ascertain (1) the present level of scientific literacy of the Georgia sample; (2) the item performance of the Georgia sample when compared with the performance of equivalent-grade students in the normative group on specific test items; and (3) the relation of the independent variables (gender, race, school system size, and geographic location of the school system) on the aquisition of scientific literacy.

Scientific literacy as measured by the Georgia Test of Scientific Literacy was considered as the dependent variable for this study. The present level of scientific literacy of the Georgia sample was determined to be below the mastery criterion of 70 percent accuracy for all three grade levels tested. In the comparison of the Georgia sample with the national sample on selected science items, the scores of the Georgia sample were significantly different from the national sample on sixty percent of the items. Results of t-tests for total test scores were significant ($p \leq .05$) for gender, race, school system size at all three grade levels tested, and for geographic location of the school system at the fourth-and eighth-grades.

Session G-3

SCIENCE INTEREST OF MIDDLE AND SECONDARY SCHOOL STUDENTS IN UTAH

J. Hugh Baird
Reuven Lazarowitz
Brigham Young University
Provo, Utah 84602

In today's junior and senior high schools, students expect more voice in decisions about what they study. They want to get knowledge and skills which will be of worth to them-either usefulness in their vocational decisions or usefulness in solving their daily problems. To the degree that subjects studied are seen as worthwhile, then both motivation to learn and trust in the school and teacher may increase.

This research was conducted since there is a decrease in student interest in science and enrollment is down in secondary science classes. It sought answers to two general questions: (1) What are junior and senior high school students' preferences and choices regarding science subjects? (2) Are there differences regarding preferences and choices related to the type of school attended (urban, suburban, and rural), the maturity of the student (grades 6-12), or the gender of the student? Information collected could attribute to a more balanced science curriculum which could reflect not only scientists' and curriculum writers' opinions but students' needs and interests too.

Approximately 2000 students evenly distributed from grade six (now a part of many of Utah's middle schools) through grades twelve were questioned. There were 914 girls and 940 boys. 603 students were enrolled in urban schools, 753 in suburban, and 498 in rural schools.

All students completed a two page questionnaire. To avoid influencing their responses students were directed to think of and then "list five science subjects which you would most like to study in school, in order of preference." Demographic information regarding school attended, grade in school, and gender were also obtained. The data collected were analyzed using frequency tables and chi-square analysis.

Findings

Several trends were identified as students' preferences were compared among urban, suburban, and rural schools. The study of zoology and the human body were the two subjects most prefered by both sexes in all grades and schools. Subjects related to ecology were least preferred in all schools. The study of physics, ranked about midway in a list of eleven generalized subjects by urban students, decreased in the preferences of suburban students, and decreased even more in rural schools. The study of botany was more preferred by suburban and rural students than by the urban students.

Girls' interest in subjects relating to the human body increased steadily from grade six through twelve, while interest in the physical sciences began and remained very low. Zoology was the most preferred subject for boys; chemistry and physics, though relatively high in the lower grades, decreased; and interest in subjects relating to the human body tended to increase in senior high school, though not as much as with girls.

Some questions important for curriculum writers and teachers occur as the general findings of this study are considered. What possible causes are there to explain the relatively low status of the physical sciences and the lack of interest in ecological subjects? How can the curriculum be modified to take advantages of students' high interest in life sciences?

Session G-3

SCIENCE NEEDS ASSESSMENT: A STATEWIDE APPROACH

Piyush Swami
University of Cincinnati
Cincinnati, Ohio 45211

Stanley L. Helgeson
Lawrence L. Gabel
The Ohio State University
Columbus, Ohio 43210

This presentation describes the development procedures, test administration, data analysis, and future implications of a statewide needs assessment effort in the State of Ohio. A representative sample of educators was asked to develop a science test for grade 8 which reflected the diversity of programs in the state. The development procedures involved collecting objectives from existing sources followed by a field review by 100 educators. Twenty-five objectives were ultimately selected. This was followed by the generation of a list of approximately 250 test items pertaining to the objectives. After looking at the field test results, a final test containing 114 items was developed.

The test was administered in 152 schools in Ohio in April, 1979. The schools were selected using a "two-stage cluster sampling" procedure. The schools included in the sample were representative according to community size, socioeconomic status, and minority/non-minority composition of the schools. Students in each school were chosen using a random selection procedure.

The test was used to determine the statewide needs in science at the 8th grade level. Four content domains were included: (1) Physical Science; (2) Life Science; (3) Earth Science; and (4) Integrated Topics.

Areas of strength and weakness were determined based upon detailed analyses and comparisons of the actual scores to predetermined minimal and optimal expectancy levels. The results pointed out that students' performance was best in the domain of Integrated Topics, which included items on science processes. Earth Science concepts were next best understood. The remaining two areas, Physical Science and Life Science, were definitely the weaker areas in terms of student achievement. Only five out of a total of fourteen objectives in these two areas met or exceeded the minimal expectancy levels.

Based upon test results and detailed item analyses, it is possible to further refine the instrument for use in additional needs assessment efforts at the state or district levels. Two strategies to be employed by school districts as a follow-up of the statewide needs assessment are currently available.

Session G-4

FACILITATING PROBLEM SOLVING IN HIGH SCHOOL CHEMISTRY

Dorothy L. Gabel
Indiana University
Bloomington, Indiana 47405

Robert D. Sherwood
New York University
New York, New York 10003

One of the basic skills required of high school chemistry students is problem solving. Students frequently lack proficiency in this area, yet little research has been conducted which examines strategies that might be used to improve students' problem solving skills. The major purpose for conducting this study was to determine whether certain instructional strategies were superior to others in teaching high school chemistry students' problem solving in four topics integral to every chemistry course. This research was supported by NSF.

The effectiveness of four instructional strategies for teaching problem solving to students of various proportional reasoning ability, verbal and visual preference, and mathematics anxiety were compared in this aptitude by treatment interaction study. The strategies used were: (1) the factor-label method; (2) the use of analogies; (3) the use of diagrams; and (4) proportionality.

The subjects of this study were 609 high school students in nine schools in Central and South Central Indiana. Students (who were randomly assigned to one of the four teaching strategies within each classroom) used programmed booklets to study the mole concept, the gas laws, stoichiometry, and molarity. Problem solving ability was measured by a series of immediate post-tests given after each lesson of each instructional unit, delayed post-tests given within two weeks of each unit, and the ACS-NSTA Examination in High School Chemistry administered at the end of the year.

Students' aptitudes were measured at the beginning of the school year using a verbal-visual preference scale developed by Pavio (1971), the Mathematics Anxiety Rating Scale, and a modified form of a proportionality test developed by Staver. Data were analyzed using multiple linear regression techniques.

Results of the research confirm the work of Barnes (1977) and Sherwood and Gabel (1980) that showed that mathematics anxiety is negatively correlated with science achievement. Results also indicated that problem solving ability in chemistry is dependent on students' proportional reasoning ability. Students' visual and verbal preference had only one significant effect on problem solving in general with visual students performing better on the molarity immediate post-test.

Certain teaching strategies for the general population were found to be preferable to others in the teaching of particular science concepts. The factor-label method was the most desirable and proportionality method the least desirable for teaching the mole concept. However, the proportionality method was better for teaching the gas laws whereas the analogy method was the worst.

The analogy method was superior for teaching students with particular characteristics: (1) low visual preference and high verbal preference; (2) high mathematics anxiety and low verbal preference; and (3) high mathematics anxiety and low proportional reasoning. Teachers should consider these student characteristics when determining which approach they will use to teach particular chemistry topics.

REFERENCES

Barnes, G. "Scores in a Piaget-type of Questionnaire Versus Semester Grades for Lower Dimension College Physics Students." American Journal of Physics, 1977, 45: 841-847.

Pavio, A. Imagery and Verbal Process. New York: Holt, Rinehart and Winston, 1971.

Sherwood, R. D., and Gabel, D. L. "Basic Science Skills for Prospective Elementary Teachers: Measuring and Predicting Success." Science Education, 1980, 64: 195-201.

Session G-4

THE EFFECTS OF THE MASTERY PARADIGM ON SUMMATIVE PERFORMANCE IN A HIGH SCHOOL BIOLOGY LABORATORY COURSE

William S. Kushner
Syracuse University
Syracuse, New York 13210

Purpose

The purpose of this study was to evaluate, in a high school biology laboratory course containing students of widely differing abilities, the effectiveness of a mastery learning strategy in promoting cognitive growth as measured by a mid-course and end-of-year laboratory practical examination.

Methods and Procedure

Nineteen classes of tenth-grade biology students (N=430) were involved in this study; there were 10 sections of A level (average and above average students) and 9 sections of B level (below average students). A unique feature of this study was the laboratory setting, common to all students. To insure proper representation for both levels and treatment groups, students in each biology class were randomly assigned to the treatment (mastery) group or to the control group. Students in each group were then randomly assigned to specific times and days in the biology laboratory. Each group of approximately 30 students had a random assortment of mastery and non-mastery students from both A and B level classes as a result of these selection processes.

A laboratory manual, developed and pilot-studied during the previous five years, was given to every student at the beginning of the school year. Each exercise contained an introduction, objectives, procedure, questions, and a data sheet for the recording of relevant information. Evaluation of learning took place on a weekly basis by means of quizzes at the conclusion of each experiment. A teacher assistant located in an adjoining room, hired specifically for this purpose, was in charge of testing. Students in the mastery group had the option of taking as many as three parallel quizzes for each experiment to reach or exceed the 80% criterion level. The students in the control group were allowed to take only one quiz for each experiment.

A computer program developed for this study enabled the investigator to closely monitor the evaluation process by determining the following data for each laboratory exercise: (1) Subkoviak reliability coefficients for each of the 16 parallel quizzes; (2) percentage of students reaching mastery; and (3) group means and standard deviations for both A and B level mastery and non-mastery students. Additionally, figures were generated to show percentages of A and B level students who availed themselves of the second and third quiz.

Summative laboratory practical examinations were given to all students in January and again in June. An analysis of covariance, using the DAT combined score of Verbal Reasoning and Numerical Ability as the concomitant variable, was performed to analyze the results of both examinations. A

multiple regression analysis was employed to determine relationships among selected variables. An attitudinal questionnaire was also given to mastery students during the last week of the academic year. The results of the questionnaire were divided into four groups: (1) mastery A level males; (2) mastery A level females; (3) mastery B level males; and (4) mastery B level females. The Hotchberg Extension of the Tukey A procedure was used to test for significant post hoc contrasts.

Results

1. There was no significant difference on either summative examination in the adjusted means between A level mastery and A level non-mastery students, or B level mastery and B level non-mastery students.

2. For each summative examination, if averaged over both A and B level students, the adjusted mean achievement scores for both groups were not significantly different. The simultaneous error rate for these tests was $\alpha_c \leq .05$.

3. The attitudinal questionnaire provided evidence that most mastery students were very positive about their approach in the laboratory. Without exception, where significant differences in attitudes were noted, females were more positive than males.

Conclusion

Mastery learning in a high school biology laboratory appears to be an alternative which is not better or worse than a more traditional approach. However, with all the effort needed to write, implement, and run a mastery laboratory program, one would doubt the value of such a venture.

Session H-1

A REPORT ON THE 1977-80 PROJECT LEO STUDIES OF QUANTITATIVELY-DEFINED SCIENCE TEACHING STRATEGIES

Charles C. Matthews
Dorothy Schlitt
Florida State University
Tallahassee, Florida 32306

Charlie L. Ray
Marshalltown Community College
Marshalltown, Iowa 50158

Objectives

Project LEO is a research cooperative which has been studying science learning environments and outcomes for the last twelve years. It is recognized that the physiological state and the mental/emotional state of the student are intimately related and interdependent and that these states are manifested in the behavior of the student. Project LEO has recognized and pursued the relationships between student behavior and teacher behavior as well as certain process and product oriented aspects of learning outcomes in science. These studies examine quantitatively-defined teacher behavioral patterns in elementary, secondary, and post-secondary science classrooms in terms of student behavior and cognitive, psychomotor and affective learning outcomes. During the last two years, Project LEO has continued to study two specific quantitatively-defined teacher behavioral patterns in these situations and in terms of these student characteristics. It has also studied specific variations on these two patterns and has studied these in specialized situations.

Summary of Methods

During 1968-72, activities of Project LEO focused on developing and validating the parameters of what has come to be referred to as "student-structured learning in science" (SSLS) strategies, defined in terms of specific teacher behaviors. During this same period, field studies revealed that science is most often taught via highly directive teacher behavior patterns. This pattern was also defined in terms of specific teacher behaviors and has been identified as "teacher-structured learning in science" (TSLS). Since 1972, laboratory studies have been conducted with over 1000 students and 40 teachers. Through teacher training and continuous teacher observation, teacher behavioral patterns have been maintained within the parameters of the quantitative definitions of TSLS and SSLS. Various dependent variables have been studied--including student behavior, student achievement, attitude toward science, locus of control, creativity, disruptiveness, confidence, problem solving ability, motivation, critical thinking, abstract reasoning, and others. Other independent variables have included time-of-day, sex, ethnicity, cognitive level, etc. The 1977-80 studies which have not been presented or published previously focus on science teaching strategies and learning outcomes for disruptive elementary school children and on more refined application of the SSLS teacher behavioral pattern in secondary school science classrooms.

Results

Findings have consistently indicated that students studying science under SSLS conditions exhibit higher levels of the following: problem solving ability, problem solving confidence, self-initiativeness, self-directiveness, verbal creativity, and positive attitude toward science and toward independent learning. TSLS students exhibited higher levels of: attention to the teacher, imitation of the teacher, copying other students, initiating interaction with the teacher, and disruptiveness. Information acquisition and general achievement in science seem to be about the same for SSLS and TSLS-taught students. Although Project LEO studies so far have consistently indicated that students are more independent and fully functioning under SSLS than under TSLS conditions, there are specific indications that certain specific sub-groups of students are more severely deprived under TSLS conditions than are other sub-groups of students. For example, black male students scored highest on certain measures of learning if taught by SSLS but scored lowest on those measures if taught by TSLS. Studying various "versions" of the SSLS strategy has indicated specific effects on critical thinking and abstract reasoning.

Implications

Science educators who wish to enhance creativity, problem solving ability, problem solving confidence, student initiative, student-directiveness, positive attitude toward science and toward independent learning, and what might be called holistic science learning should take the necessary training to be able to implement a consistent SSLS strategy. Those science educators who wish to accomplish information acquisition alone should choose either SSLS or TSLS. Science educators who wish to make science learning equally available to both black and white students of both sexes should implement a consistent SSLS strategy. Those who wish to maximize abstract reasoning and critical thinking should use an SSLS strategy in which higher order questions are emphasized.

Further study is needed to identify the more specific aspects of SSLS and TSLS which may be associated with the varying outcomes of the two strategies. Other strategies should be quantitatively defined and studied in the fashion of the Project LEO studies. Longitudinal studies should be carried out in a variety of different school settings. Teacher and student preferences and personality types should be studied as they relate to instructional strategy. Various strategies to assist in the "survival" of the SSLS teacher behavioral pattern should be studied, in "normal" school environments.

Session H-1

A COMPARATIVE LABORATORY STUDY OF THE EFFECTS OF LOWER LEVEL AND HIGHER LEVEL QUESTIONS ON STUDENTS' ABSTRACT REASONING AND CRITICAL THINKING IN TWO NON-DIRECTIVE HIGH SCHOOL CHEMISTRY CLASSROOMS

Charlie L. Ray
Marshalltown Community College
Marshalltown, Iowa 50158

Charles C. Matthews
Dorothy Schlitt
Florida State University
Tallahassee, Florida 32306

Objectives

The purpose of this study was to investigate the effects of lower level and higher level questions on students' abstract reasoning and critical thinking in a non-directive high school chemistry teaching strategy.

Summary of Methodology

The two learning environments were equivalent in terms of science materials, classrooms settings, and general teacher behavioral pattern. Only the cognitive levels of teacher questions were varied from one group to the other. One class was taught using a majority of higher level questions (comprehension, application, analysis, evaluation, and affective) while the other class was taught using a majority of managerial and lower level (knowledge) questions. The Science Curriculum Assessment System (SCAS) was used to define teacher behavior patterns and the Project LEO definition of "student-structured learning in science" teacher behavioral pattern was used. Managerial questions were defined in terms of Blosser's (1973) "Question Categories System of Science" and knowledge questions were defined in terms of Bloom's Taxonomy of Educational Objectives as were questions at the levels of comprehension, application, analysis, syntheses, and evaluation. Affective questions were defined in terms of Davis' and Tinsley's "Teacher-Pupil Question Inventory."

The study was conducted for 24 weeks with 54 tenth-, eleventh-, and twelfth-grade students enrolled in high school chemistry. Both verbal and non-verbal student and teacher behaviors were coded using Matthews' (1977) revised SCAS Categories. The Watson-Glaser Critical Thinking Appraisal was used with form ZM as a pre-test and form YM as a post-test. The Abstract Reasoning Test of the Influential Attitude Test was used with form S as a pre-test and form T as a post-test.

Results and Conclusions

The results of analysis of covariance indicated significantly higher performances on the critical thinking and abstract reasoning tests for the class taught with higher level questions. Also, a significant two-way interaction between teacher behavior and grade point average variables in the abstract reasoning ability analyses show that both students with high and low grade point averages did better in the classroom taught with higher level questions.

This study has provided tentative answers to the questions which were stated above and suggests that further research is needed to answer such questions as the following:

1. What sequence of question levels should be used in science discussions?
2. Are teachers' use of higher or lower level questions based on the curriculum materials available to them?
3. What questions are appropriate for science classes in terms of student interest and cognitive and affective abilities?
4. Do non-directive science teaching strategies increase students's initiation of questions?
5. Will teacher and student training in higher level questions bring an increase in the students' understanding of science?
6. Is there a relationship between the kinds of questions students ask and evidence of good science teaching in a given classroom setting?
7. Should students be trained or should they be allowed to develop without specific training in question-asking skills?
8. Do directive strategies with higher level questions increase students' abstract reasoning and critical thinking abilities?

REFERENCES

Blosser, Patricia E. Handbook of Effective Questioning Techniques. Worthington, Ohio: Educaton Associates, Inc. 1973.

Mathews, C. C. Student Structured Learning in Science (3rd Edition). Dubuque, Iowa: Kendall, Hunt Publishing Company, 1977.

Session H-2

THE FREQUENCIES AND ORIGINS OF SCIENTIFIC MISCONCEPTIONS

Richard J. Trembath
State College of Victoria at Frankston
Frankston, Victoria Australia 3199

James P. Barufaldi
University of Texas at Austin
Austin, Texas 78712

The existence of people who believe particular scientific misconceptions has been documented over three centuries. Possession of such misconceptions may be a handicap to those who live in a democratic industrial society.

The present study (1) identified certain scientific misconceptions possessed by high school and university students; (2) identified, by written and interview means, the origins of these misconceptions; and, (3) classified the misconceptions according to their origin.

All earlier studies of scientific misconceptions suffered from at least one of the following defects: (1) Only anecdotal evidence was used to show the existence of the misconceptions; (2) Trivial concepts, superstitions, and folklore were tested (many of which were of bizarre interest only); (3) Only a small number of students were tested (or none at all); (4) The test did not allow students to answer "I do not know"; and/or (5) the structure of the test had defects (e.g., the answer to all true/false items was "false"). All of these defects were overcome in the present study.

A pilot study using Grade 9 high school students showed that, although more time-consuming, a clinical interview yielded more information about the origins of misconceptions than a request for written information about the origins.

A final instrument, the Trembath Test of Scientific Misconceptions (TTSM) consisting of 16 true/false items, 15 multiple choice items, and 6 brief written statements was administered to 47 college students.

The TTSM was shown to have a satisfactory reliability. The validity of the test was measured by sampling techniques and by the judgements of a group of science educators.

Results from the administration of the TTSM showed that, for the college students in the sample, the high achieving students were less likely to use the option "I do not know" than the lower achieving. A clinical interview technique revealed the origin of 97.7% of the misconceptions that were detected. The number of semester hours of science taken at grade 10 level correlated positively with the number of misconceptions possessed and the number of credit hours of science taken in upper divsion of college correlated

negatively with the number of misconceptions possessed. A classification of the origins of misconceptions was made and used reliably by trained judges, and the existence of misconceptions seems to be a widespread phenomenon as the performance on the final instrument by American and Australian students did not differ significantly.

Session H-3

THE COMPARATIVE EFFECTS OF CONGRUENT AND INCONGRUENT TEACHER VERBAL BEHAVIOR ON HIGHER LEVEL LEARNING OUTCOMES OF SECONDARY BIOLOGY STUDENTS DURING DISCOVERY/INQUIRY LABORATORIES

James A. Botti
H. Seymour Fowler
Pennsylvania State University
University Park, Pennsylvania 16802

The purpose of this study was to evaluate whether congruency or incongruency between a teacher's intended discovery/inquiry laboratory instructional strategy and his actual behaviors used to implement that strategy had an effect on higher level learning by students.

The mixed findings of earlier research on the effects of laboratory instruction on pupil learning and the suspicion that teachers do not, in fact, conduct discovery/inquiry strategies as intended, encouraged this author to examine teacher's verbal behavior during science laboratory instruction. Existing studies appear to avoid verifying what sorts of interactions are actually occuring under the label of "laboratory experience." Hence, it appeared necessary to question whether the teacher's verbal behavior during science laboratory instruction is a relevant variable when determining the effect of science laboratory instruction on students' higher level learning.

Aside from the question of importance of congruent and incongruent instruction, two additional problems remained: (1) did the earlier research evaluate the appropriate higher level learning outcomes; and (2) was the method of evaluating laboratory learning appropriate for assessing that learning. Consequently, this study assessed whether student performance on science projects can be an effective means to discriminate previously undetected student differences in higher level cognitive abilities relative to the understanding and use of science processes.

The seventy-two subjects used in this study were selected randomly from a population of high school students scheduled to take their first course in high school biology. Four class sections were established and two sections were treated by an instructor employing congruent laboratory verbal behavior while the remaining two sections received incongruent laboratory verbal treatment. The experimental design was the Solomon Four Group Design. Four groups were developed. Two groups were pre-tested using the Science Process Inventory, and two groups were pre-tested using the Allison Adaption of the "Allen Attitude Scale." Congruent and incongruent teacher verbal behaviors during laboratory sessions were assigned and subsequently assessed by the systematic analysis of audio-tape recordings of randomly selected laboratory sessions.

Following twenty-four weeks of experimental instruction, judgements concerning the effects of contrasting teacher verbal behaviors during the laboratory sessions were made on the student's performance designing and developing science projects and measured by: (1) the Science Project Evaluation Criteria; (2) Welch's Science Process Inventory; and (3) the Allison Adaption of the "Allen Attitude Scale."

A two-way analysis of variance was employed for the analysis of treatments and type of pre-tests on the Science Process Inventory and the Allison Adaption of the "Allen Attitude Scale" post-test scores; and a two-way analysis of variance with repeated measures was used for the analysis of gain scores in pre-test and post-test results of the Science Process Inventory and the Allison Adaption of the "Allen Attitude Scale." Finally, the null hypothesis concerning pupil performance on science projects was tested using an independent sample t-test for the analysis of the Science Project Evaluation scores.

The following findings are reported ($p \leq .05$): (1) the subjects, regardless of the teacher laboratory verbal treatment, did not differ statistically in mean score performance on understanding science as measured by Welch's Science Process Inventory or on scientific attitudes as measured by Allen Attitude Scale. (2) The congruent treatment subjects earned significantly higher mean scores in cognitive abilities relative to the understanding and use of science processes as measured by the Science Project Evaluation Criteria than did the incongruent treatment subjects.

Session H-3

EFFECTS OF CURRICULA ON SEARCH BEHAVIORS MODELED BY SCIENCE TEACHERS

John T. Wilson
University of Iowa
Iowa City, Iowa 52242

During science instruction, students perform search behaviors as a means to find and interpert significant information. These search behaviors are often acquired by observing others model the behaviors in reponse to teacher questions or directions. However, the behaviors modeled in any particular science activity were hypothesized to be determined by the curriculum material and plan of instruction. Hence, 25 teachers meeting quality criteria were selected for each of three different science curricula--ESS, SCIS, and SAPA. Audiotape recordings of science instruction were made throughout the school year. Double repeated random sampling from these tapes provided the profiles of teaching skills for each curricula. The differences in skills matched expectations described in the curriculum materials. It would be expected then, that students in each of the curricula would be exposed to different models of search behavior.

Session H-3

A CASE STUDY EXAMPLE OF A BEGINNING TEACHERS'S USE OF CURRICULUM MATERIALS AND THE POTENTIAL OUTCOMES FOR STUDENTS

Brent Kilbourn
The Ontario Institute for
Studies in Education
Toronto, Ontario Canada M55 1V6

This paper presents an example of a beginning teacher's uncritical use of a biology text which had potentially negative consequences for students. The paper relates the teacher's behavior and potential outcomes for students to such situational factors as the teacher's stage of professional development, the text this teacher was required to use, teaching style, and the characteristics of the general-level, grade nine biology class. This paper shows the interplay between substantive content issues in the discipline of biology and more strictly pedagogical issues relating to the teacher's intentions and performance in order to make a more general point concerning in-service teacher education. It is argued that one function of in-service education would be to help teachers develop awareness and skill concerning the appropriate modification of curriculum materials. The data for the paper come from the author's three month involvement with the teacher using the strategies and techniques of clinical supervision.

REFERENCES

Kilbourn, Brent. "Ethnographic Research and the Improvement of Teaching." In Seeing Curriculum in a New Light: Essays from Science Education; Munby, H., Orpwood, G., and Russel, T., (eds.) Toronto: OISE Press, 1980.

Goldhammer, Robert. Clinical Supervision: Special Methods for the Supervision of Teachers. New York: Holt Rinehart and Winston, 1969.

Session H-4

THE COGNITIVE DEVELOPMENTAL LEVEL OF ELEMENTARY SCHOOL STUDENTS IN TRINIDAD AND TOBAGO

Pamela Fraser-Abder
University of the West Indes
Saint Augustine, Trinidad

H. Seymour Fowler
Pennsylvania State University
University Park, Pennsylvania 16902

The purpose of the present study was to investigate the cognitive developmental level of Elementary School students in Trinidad and Tobago.

The subjects included 6686 students randomly selected from the various school types, localities, and cultural, social and racial backgrounds in Trinidad and Tobago. The age range was from 5 to 15 years.

The investigation involved only a post-test. The Concepts in Secondary Mathematics and Science Programme (CSMS) at England's Chelsea College, Centre for Science Education, has developed a set of class tasks called Science Reasoning Tasks for assessing the cognitive level of pupils. Operational Task No. 1 used in this study has been recommended for use with elementary students.

CSMS Task 1 was administered as a pilot study to 30 randomly selected students who were later subjected to an interview designed by Trojcak (1979) and based on Piagetian type tasks for assessing levels of cognitive development. A high correlation of .89 was found between the results of Task I and the Trojcak interview; therefore, it was decided to use CSMS Task I in this study based on these results.

The results show a steadily decreasing proportion of students from age 5 to 11 at the preoperational stage. At the transitional stage, a steady increase to age 10 followed by some fluctuation ending with a high proportion in this stage at age 15 was found. The concrete stage showed an increase to age 11 followed by a decrease to age 15. A similar trend was noted for the transitional stage between concrete and formal stages.

The following conclusions seemed warranted. From a consideration of the results:

1. It was possible to classify individuals into the stages of cognitive development suggested by Piaget. This conclusion was substantiated by the fact that 53.8% of the subjects studied were readily classified as preoperational, 34.6% as transitional to concrete, 10.7% as concrete, and 0.9% as to transitional to formal;

2. Although the fundamental validity of Piaget's classification of concept stages has been demonstrated, the data have revealed the impossibility of limiting the age range of the stages as Piaget has attempted to do. This fact was apparent from the complete coverage of the entire mental and chronological age ranges within each one of the concept stages.

REFERENCE

Trojcak, A. Doris, Science with Children. St. Louis: McGraw-Hill Book Company, 1979.

Session H-4

USING THE INTENSIVE TIME-SERIES DESIGN FOR ASSESSING LEARNING OF CRUSTAL EVOLUTION

Victor J. Mayer
The Ohio State University
Columbus, Ohio 43210

Carlos A. Rojas
Colciencias
Bogota, Columbia, South America

Early stages in the testing and development of an intensive time-series design for use in science classes has been reported by Mayer and Lewis (1979) and Mayer and Kozlow (1980). The first study indicated the feasibility of using the design for assessing the efforts of teaching methods upon student attitudes toward the science class. The latter found the anticipated learning curve when the design was used to assess changes in knowledge related to the study of crustal evolution, indicating the design would yield valid achievement data. Several questions raised in the second study are addressed in the one reported here. Does frequency of testing affect the validity of achievement data in the design? Can the results of the Mayer and Kozlow study be replicated, thus adding to the confidence in the design's ability to yield valid data?

A multiple-group, single-intervention time-series design (Glass, et al., 1975) was modified for intensive classroom use. The unit on the topic of crustal evolution was modified from that used in the Mayer and Kozlow study and became the intervention of ten days. The item pool generated for that study was also modified to function in data gathering during the intervention, a ten day baseline period preceding the intervention, and during the ten day follow up succeeding the intervention.

The four classes (89 students) of an earth science teacher from a suburban Columbus school provided the subjects for the study. The students in each of four classess were randomly assigned to one of three frequency groups. Frequency group A was tested every day, group B about every fourth day, and group C about every tenth day.

Frequency Study

The independent variable for the frequency study was the frequency of testing. The criterion variables were achievement in crustal evolution and attitudes toward the science class. It was anticipated from previous studies that one of two things might happen. First, students might become familiar with the items leading to enhanced performance with time and frequency of testing. On the other hand, Cook and Campbell (1979) have identified an effect termed "resentful demoralization," i.e., students become negative toward frequent testing. If this should occur with the intensive time-series design, a decline in performance with frequent testing should occur over time.

Trend analyses were performed on the data from each of the three frequency groups. Correlations of achievement data between group A and group B, group A and group C, and group B and group C were tested for significance. No significant differences were observed. A similar analysis was performed on the attitude data, with similar results. It can be concluded, therefore, that frequency of testing does not seem to lead to either positive or negative trends in series achievement data when using the intensive time-series design developed for this and previous studies. Especially significant was the failure of "resentful demoralization" to set in as demonstrated by the lack of negative correlations in the attitude data and supported by interviews with randomly selected students, conducted at the end of the study.

Replication Study

Data from Frequency group A was further analyzed to determine whether trends observed in the Mayer and Kozlow data were also observed in this data. The unit on crustal evolution was the independent variable and achievement in crustal evolution the criterion variable. A time-series analysis program (Glass, et al.,1975) was performed. A learning curve during intervention would be supported by a statistically significant difference in level between baseline and intervention data. Such a difference was observed ($p \leq .05$). If the "momentum effect" (Mayer and Kozlow, 1980)--continued learning after the cessation of the intervention--occured, there should be a more highly significant change in level between baseline and follow-up. Again, such a change ($p \leq 0.01$) was observed. It would appear therefore, that the data from this study are consistent with those from the Mayer and Kozlow study, thereby adding confidence to the validity of this design when attempting to monitor achievement in a science concept.

REFERENCES

Cook, D., and Campbell, D. T. Quasi-experimentation: Design and Analysis of Issues for Field Settings. Chicago: Rand-McNally College Publishing Company, 1979

Glass, G. V , Willson, V. L. and Gottman, J. M. Design and Analysis of Time-Series Experiments. Boulder, Colorado: Associated University Press, 1975.

Mayer, V. J., and Lewis D. K. "An Assessment of the Validity of the Use of a Time-Series Single Subject Design." Journal of Research in Science Teaching, 1979, 16: 137-144.

Mayer, V. J., and Kozlow, M. J. "An Evaluation of a Time-Series Single Subject Design used in an Intensive Study of Concept Understanding." Journal of Research in Science Teaching, 1980, 17: 455-461.

Session H-5

DETERMINING THE POWER OF STATISTICAL TESTS AND SAMPLE SIZES FOR RESEARCH STUDIES

Rosalie Grant
Mid-Peninsula High School
Palo Alto, California 94306

Statistical theory provides guidelines for answers to two questions frequently asked by a researcher who is designing a study. These questions are:

1. How many subjects should be selected?
2. How can the probability of committing a Type I or a Type II error be controlled?

The statistical theory from which these questions can be answered will be discussed. Participants will then apply the theory to some research case studies.

Of the two error types, frequently the consequences of Type II errors are more educationally harmful than Type I errors. Participants will therefore learn to consider the consequences of committing each error type and decide which error is potentially more harmful if incorrect research conclusions are applied in the classroom. Because Type II errors are indirectly controlled through the power of a test, the concept of power and how it can be calculated for different tests will be discussed. The Pearson-Hartley charts (1951) will be used to determine the power of ANOVA tests and Cohen's charts (1969) will be used for other tests, such as X^2 and correlation coefficients. Formulae will be provided for computing the power of one-way through three-way ANOVA tests for equal and proportional cell sizes. Because of the relationships between power and sample size, participants will compute cell sizes which provide tests with a desired power for selected differences between population means.

Activities and handouts will be included in the session. All participants should bring a calculator which has four basic functions and a square root key.

REFERENCES

Cohen, J., Statistical Power Analysis for the Behavioral Sciences. N.Y.: Academic Press, 1969.

Pearson, E. S. and Hartley, H. O. "Charts of the Power Function for ANOVA Tests Derived from the Non-central F Distribution." Biometrika, 1951, 38.

GENERAL SESSION III

NATURALISTIC INQUIRY AND CONVENTIONAL INQUIRY: AN EVALUATION

Wayne W. Welch
University of Minnesota
Minneapolis, Minnesota 55455

Session I-2

A MODEL OF CLASS INCLUSION DEVELOPMENT BASED ON SUBJECTS' VERBAL JUSTIFICATIONS

Jean Sindhikara
Rutgers University
Lakewood, New Jersey 08701

The nature of the transition to fully operational class inclusion understanding has been the subject of much research since Piaget's original descriptions of this concrete level concept. The results of this study suggest a gradual transition from early incorrect solutions to a sophisticated abstract understanding of Piaget's class inclusion problem through three major levels. The levels were described following analysis of the kinds of justifications given to explain both correct and incorrect answers to the standard class inclusion question, Are there more A's or more B's here? given a set of objects, B, containing two subsets, A and A^1, where A is the larger subset.

It was hypothesized that the kind of justification type used to explain answers to the standard class inclusion question reflected the kind of understanding a child had about class inclusion and that development in justification type use therefore reflected development in class inclusion understanding. Three types of justifications emerged from an analysis of all those given to explain answers. The three types were called spatial/counting, addition, and sets. Development in justification type use in the order spatial/counting, addition, and then sets was hypothesized to occur.

Support for the hypothesized kind of development was obtained when it was shown that both age and class inclusion task solution ability increased as justification type was changed in the order spatial/counting, addition, and sets. Children were asked to justify answers to three class inclusion questions. Analyses were able to show a statistically significant correlation between the types of justifications used and the age of the subject and also between the types of justifications and success on two different groups of class inclusion tasks.

Three levels of class inclusion understanding described by the model and supported by the results thus emerged. At the lowest cognitive level of class inclusion understanding are children who think about the problem in terms of perceived or visible qualities of the task objects and who justify their answers by spatial/counting arguments. The second level is that of children whose thinking reflects understanding of the reversibility of the class-subclass relationship and who use addition type arguments to support their answers. At the third level in understanding class inclusion, according to the model, are those children who think about the problem in terms of the abstract qualities of a particular class. They explain their answers by sets type justifications.

Session I-2

OBJECTIVE MEASURES OF COGNITIVE AND MORAL JUDGMENT LEVEL IN BIOETHICS

John Finley
Cooperative Educational Service Agency
Griffin, Georgia 30224

Cheri M. Taylor
Springfield, Virginia 22152

Purpose

Bioethics can be defined as the systematic study of value questions which arise in the biomedical and behavioral fields. The researchers believe: (1) that an assessment instrument of the awareness of the general public regarding bioethical issues is a necessary prerequisite to possible social and political actions resulting in governmental intervention; (2) it is also desirable to assess the awareness of the educational community before undertaking curriculum developments or innovations concerning the teaching of bioethics; and (3) that science educators may enhance a student's cognitive-developmental structure for resolving bioethical issues and determining possibilities of action in regard to scientific advancement by teaching science in its social context. This paper is a collaborative effort to synthesize two separate, but related sudies which describe an objective instrument developed to assess level of principled moral thinking relating to bioethical issues.

Methodology

A. Respondents (n=768) were assessed initially in regard to the cognitive aspects of two bioethical issues--experimenting with recombinant DNA and genetic engineering. The individual scores of the items were summed and averaged to yield a mean score of value indicators for each item. All data were subjected to analysis using the Statistical Package for the Social Sciences (SPSS). An examination of the central tendencies of the sub-population was provided by the subprogram breakdown.

B. An objective instrument to assess degree of principled moral thinking in bioethics was developed using James Rest's (1974) Defining Issues Test as a model. During the pilot phase of development, construct validity and reliability were determined for the instrument, named the Bioethical Issues Test. "P" scores were obtained on a heterogeneous sample of Georgia State University students (n=151). SPSS statistical analysis was used to determine correlation of moral judgement development in bioethics and the sample characteristics sex, age, college major, grade point average, college class, and religious attendance.

Results

A. The mean score for respondents on the cognitive aspects, based on a 16 point multiple-choice test, was 7.5 for education majors, 5.8 for arts and sciences majors, and 10.8 for respondents enrolled in a science and society class. The mean responses for certain specific affective questions were generally indicative of an uncertain position concerning fear of misuse and conditions for support or nonsupport of experiments with recombinant DNA and genetic engineering.

B. The Bioethical Issues Test, as validated by the D.I.T. for construct validity, had a Pearson r or .75 and an r of .852 for test-retest stability. The mean P score (percentage) of the Bioethical Issues Test for 151 Georgia State University students was 55.80 (S.D.=13.88). Statistical analysis showed the sample characteristics of college class, college major, and grade point average to be significantly related to P score on the B.I.T. No significant relationship between P score and age, sex or religious attendance was indicated by Bioethical Issues Test data.

Conclusions

A. The data revealed that the majority of the respondents possessed a minimum of knowledge concerning recombinant DNA and genetic engineering and were generally apprehensive about advances in genetic technology. However, the respondents were overwhelmingly in favor of knowing about their genetic condtions rather than leaving their genetic future to fate.

B. The Bioethical Issues Test is an objective measure of level of moral judgment of college students in bioethics. Based on evidence from this instrument the sample characteristics of college class, grade point average, and college major are related to moral judgment level in bioethics.

REFERENCE

Rest, J. R. Constructing the Defining Issues Test. Unpublished manuscript, University of Minnesota, 1974.

Session I-2

AN INVESTIGATION OF THE RELATIONSHIPS BETWEEN STUDENTS' SELF CONCEPT, MENTAL MATURATION, DEGREE OF OPENMINDEDNESS, AND THE NUMERICAL VALUES THEY ASSIGN TO INDEFINITE QUANTITATIVE WORDS AND EXPRESSIONS

Pastor R. Rojas
Ninoska R. Rojas
Michael Duffy
University of Pittsburgh
Pittsburgh, Pennsylvania 15260

This paper reports the results of the investigation of the influence that eighth-grade students' self concept, mental development, and degree of openmindedness may have in the numerical values they assign to the following words and expressions: "most," "few," "many," "some," "all," "none," "every," "a lot," "more than half," "several," and"quite a few." These words and expressions, which refer to quantities without specification of distinct limits or exact numbers, are frequently used in the teaching of science when communicating information and laboratory instructions. Confusion, misunderstanding, or at least inaccurate communication may result when the meaning of these terms used by a science textbook writer or a science teacher is at variance with the meaning assumed by the student.

Students were given the Piers-Harris Children Self Concept Scale (1969), the Piagetian type battery developed by Moser (1975), the Shipley test on abstract reasoning (1940), the E-Form of Rokeach's dogmatism scale (1960), and a form similar to the one used by Simpson (1963) for the assignment of numerical values to the indefinite quantitative terms and expressions.

The results of a cluster analysis led to the conclusion that there exist relationships between students' self concept, mental development, degree of openmindedness, and the numerical values they assign to the indefinite quantitative words and expressions. The levels of significance of these relationships range from $p \leq .05$ to $p \leq .01$. Multivariate regression led to the following findings:

1 These are the percentages of the variance of the values assigned by the students to the words, that can be explained by their:

a. degree of openmindedness as measured by Rokeach's categories:

FEW:	37.56%;	$F = 2.23$	$p \leq .01$
SOME:	33.74%;	$F = 1.89$	$p \leq .05$
ALL:	45.88%;	$F = 3.14$	$p \leq .01$

Degrees of freedom = 17,63.

b. mental maturation as measured by the Piagetian type battery:

MOST:	29.49%;	F = 3.77	$p \leq .01$
FEW:	24.02%;	F = 2.85	$p \leq .01$
ALL:	26.34%;	F = 3.22	$p \leq .01$
EVERY:	19.86%;	F = 2.23	$p \leq .05$
MORE THAN HALF:	30.71%;	F = 3.99	$p \leq .01$
SEVERAL:	21.74%;	F = 2.50	$p \leq .05$
QUITE A FEW:	19.74%;	F = 2.21	$p \leq .05$

Degrees of freedom = 8,72

c. mental maturation, as measured by the Shipley test:

ALL: 32.52%; F = 3.80 $p \leq .01$

Degree of freedom = 9,71

2. It was found that the subscores developed from the Piers-Harris test do not explain the variance of the numerical values assigned by the students to the indefinite quantitative words and expressions.

This study may be considered an attempt to identify variables which may help in the improvement of communicating scientific information in the teaching of science and to better understand the relationships between the process of communication and (1) students' mental development; and (2) the affective domain.

REFERENCES

Moser, G. W., Personal Communication, University of Pittsburgh, 1975.

Piaget, J., The Child's Conception of the World, Littlefield, Adam and Co., Toweta, N. J., 1963.

Piers, Ellen V. and Harris, Dale B., Manual for the Piers-Harris Children's Self Concept Scale, Counselor Recordings and Tests. Nashville, Tennesee, 1969.

Rokeach, Milton, The Open and Closed Mind.New York: Basic Books, Inc, 1960.

Simpson, R. H. "Stability in Meaning for Quantitative Terms. A Comparison Over Twenty Years." Quart. Journal of Speach, 1963, 49

Shipley, Walter C., "A Self-Administering Scale for Measuring Intellectual Impairment and Deterioration." Journal of Psychology, 1940, 9

Session I-3

FORMAL OPERATIONAL REASONING: FORMAT, CONTENT, AND INTERVENTION

Jane Bowyer
Mills College
Oakland, California 94613

Robert Karplus
Steven Pulos
Elizabeth K. Stage
University of California
Berkely, California 94720

Marcia C. Linn
Stanford University
Stanford, California 94305

Research studies indicate that few high school students use strategies of formal thought confidently and reliably. Yet analyses of secondary science texts reveal that formal thinking is required for understanding. Because most students learn science "from the book," concepts are often understood superficially at best.

In this symposium researchers approach the problem from two directions. Two research groups will discuss studies that examine the effects of problem format and content on complex problem solving. A third group will report on a study evaluating the effects of inservice workshops designed to teach intervention strategies which encourage formal thinking in students. The groups studying the format and content effects on problem solving have studied problems from different content areas (e.g., mathematical, scientific, and everyday problems) and have used different methodologies (e.g., writing as problem solving, problem solving during an interview, and problem solving on paper and pencil tests). Each group has grappled with the relative importance of content as opposed to generalized reasoning strategies on performance.

In proportional reasoning findings suggest that task format has little effect and that performance is content specific rather than developmental. In another study investigating performance on tasks with content from both laboratory and naturalistic domains, there are indications that content systematically influences performance. In a third study concerned with the way naturalistic and laboratory content might influence scientific reasoning in problems requiring the Elimination strategy (allows identification of a single causal variable), performance on Elimination items was most clearly related to task content. The last study suggests that using a particular set of workshop materials can affect teacher literacy with regard to the concepts of concrete and formal thinking and self-regulation but actual application in reorganizing classroom teaching strategies to encourage a transition from concrete to formal thinking requires more than an eight hour, interactive workshop.

Session I-4

APPLICATIONS OF SCIENTIFIC AND MATHEMATICAL PROCESSES USING MICROCOMPUTERS PART II: SEX AND AGE CORRELATES TO ESTIMATION*

Carl F. Berger
The University of Michigan
Ann Arbor, Michigan 48109

First-, third-, and sixth-grade students' use of a microcomputer in solving problems of linear estimation of distance was examined. Two levels of difficulty, corresponding to different amounts of visual information in the problem, were presented. The time and accuracy of estimates were recorded; performance curves were analyzed. Accuracy in estimation was achieved by most subjects. Using the time of estimation as a measure of estimation skill, students improved performance between the levels of informational support. Across levels, performance improved and a learning practice effect appeared to occur over time. Across levels, distinct differences in student performance were noted for age but not time. At the most difficult level, third-grade students performed more like first-grade students, and at the easier level, more like sixth-graders. No differences in sex were noted.

*The research reported herein was partially supported by funds from an Horace H. Rackham grant and a Division of Research Development and Administration grant from The University of Michigan

Session I-4

THIRTY STUDIES INVOLVING THE "SCIENTIFIC ATTITUDE INVENTORY": WHAT CONFIDENCE CAN WE HAVE IN THIS INSTRUMENT?

Hugh Munby
Queen's University
Kingston, Ontario Canada K7L 3N6

The research reported in this proposed paper is an in-depth study of the Scientific Attitude Inventory (Moore and Sutman, 1970) and of the 30 studies in which the instrument has been used.

This research is an outgrowth of a major and extensive study of instruments which are purported to measure attitudes toward science. The major study identified over 200 instruments and collected the 56 which could be taken as measuring such attitudes. (Instruments not collected measured such variables as attitudes toward science careers, science instruction, and specific science issues.) In addition to the instruments themselves, all the studies in which they were used from 1969 to 1979 were procured for study. This range of instruments and studies made it possible to assess the general quality of attitude measurement in science education. The major study stopped short of a detailed investigation of any single instrument in use.

The Scientific Attitude Inventory (SAI) was chosen for the present intensive study because it is the most popular instrument of its type by far. But, although judgments about this instrument are made in the proposed paper, it should be noted that other instruments could have been selected equally well for study, to illustrate the analytical perspectives used here and their importance to our striving to improve the quality of empirical research.

A number of analytical perspectives were employed in the research. Two of these were devised from philosophy and were used to make judgments about the conceptual validity of the SAI. Using these perspectives, it was possible to show that many items which might be thought to tap attitudes can be interpreted as asking whether or not a respondent possesses some science-related knowledge, for instance, or a certain philosophical view of science. This information, when coupled with some standard psychometric properties of the SAI, is then used to interpret the instrument's performance in 30 research studies.

It is found that these research studies reveal a wealth of information: (1) There are conflicting results when similar treatments are used by different investigators; (2) There are varied values of the reliability of the SAI, some of which are ignored; (3) Some studies find non-significant effects when we do not expect them, and vise versa; and (4) Some correlational studies provide discrepant information about the validity of the SAI.

It is found that some of these results can be explained in terms of the conceptual validity of the SAI. The paper concludes that we can be less than certain of what is measured by the SAI, and that it needs reworking before

it can be used with confidence. The report ends with some general concerns about attitude measurement and its place in science education research.

REFERENCE

Moore, R., and Sutman, F. "The Development, Field Test and Validation of an Inventory of Scientific Attitudes." Journal of Research in Science Teaching, 1970, 7: 85-94.

Session I-5

A QUANTITIATIVE PROCEDURE FOR TREATMENT VERIFICATION IN SCIENCE TEACHING RESEARCH

William H. Leonard
University of Nebraska at Lincoln
Lincoln, Nebraska 68588

In most studies comparing one or more methods of teaching to find which is most productive in terms of student achievement, researchers currently report that a "tight" experimental design and strict adherence to operational definitions are enough to assure that a given method was, indeed, employed. The assumption is made that if the actual treatment followed the intended method, the actual treatment occurred. It is suggested that this is not sufficient, especially if a researcher wishes to argue that differences in achievement measures (dependent variables) between treatment groups are due to actual differences in treatments (independent variable).

In a physical science laboratory experiment where sources of variance can be controlled tightly, differences in dependent variables can be attributed to the manipulation of the independent variable. But this is much more difficult to accomplish in a behavioral experiment, such as a science classroom, because teacher behavior, student behavior, and the interaction of the two are virtually impossible to control completely.

The problem of measuring "non-events" in program evaluation was raised as one explanation for the array of educational experiments reporting no significant differences between methods. A quantitative procedure has been developed to show whether differences between treatments are statistically significant in a study of two laboratory teaching approaches in high school biology. This latter procedure outlines the collection of treatment data in a systematic manner by observations of teacher-student interactions. Frequencies of various categories of classroom interactions are summed across a random series of observations and a Chi-square test for significance of differences between groups is employed.

The actual experiment occurred in a comparison study of two methods of laboratory instruction for high school biology: The BSCS Green Version Program and a newly developed Extended Discretion Approach. The independent variable was the method of laboratory instruction. Dependent variables consisted of student scores of laboratory reports, laboratory quizzes, and a laboratory final exam.

Two questions needed to be statisfied. (1) Were the differences in frequencies in the direction predicted by the teaching models? (2) Were the differences in frequencies statistically significant? The first question was answered by simple observation of the frequencies. The second question was answered by a Chi-square test of homogenity, calculated from observed frequencies of selected teacher-student interactions between the BSCS and Extended Discretion classrooms.

Two cases of data were considered. One case showed significant differences between BSCS and Extended Discretion classes on the independent variable and corresponding significance of differences on dependent variables. A second case revealed no significant differences between methods on the independent variable and also no differences on dependent variables either.

The ability to quantitatively demonstrate that specific classroom events contribute to measured changes in student productivity would greatly aid the science teaching researcher in arguments for causation. Quantitative treatment verification may be a useful step in the direction of respectable and valid science teaching research.

Session J-1

AN INVESTIGATION OF RELATIONSHIPS BETWEEN COGNITIVE PREFERENCE ORIENTATION AND JUNGIAN (MBTI) PERSONALITY TYPES OF EIGHTH-GRADE SCIENCE STUDENTS

John A. Novak
The Ohio State University
Columbus, Ohio 43210

Burton E. Voss
The University of Michigan
Ann Arbor, Michigan 48109

Rationale

The cognitive preference dimension of cognitive style as conceptualized by Heath (1964) has been used extensively to evaluate various high school science curricula. The emphasis in recent studies has focused on validating the cognitive preference construct and examining relationships between cognitive preferences and selected variables, e.g., learning styles and intelligence. However, little attention has been given to an examination of the relationships between cognitive preference orientation and personality attributes (Williams, 1975), with implications for curriculum and instruction in science.

Cognitive preference orientation as used in this study refers to (1) a preference for the recall (M), application (A), or questioning (Q) of information; (2) a combination of preferences (MA, MQ, AQ); or (3) no determinable preference (NP). Jungian (MBTI) personality types refer to one of two types across each of four dimensions:

Extravert	(E)	or Introvert	(I)
Sensing	(S)	or Intuition	(N)
Thinking	(T)	or Feeling	(F)
Judging	(J)	or Perceiving	(P)

Purpose

This study was undertaken to determine:

1. the cognitive preference orientation and Jungian (MBTI) personality types of eighth-grade science students;
2. predicted relationships between these variables:
   a. It was hypothesized that I, N, T, and P MBTI personality types would exhibit an A, Q, or AQ cognitive preference orientation, i.e., an inquiry orientation to learning.
   b. It was further hypothesized that E, S, F, and J MBTI personality types would exhibit an M, MA, or MQ cognitive preference orientation, i.e., a traditional orientation to learning.
3. if students differed on these measures according to sex or intelligence.

Procedure

Data were collected from 283 (153 male and 130 female) eighth-grade science students. Students were classified as (1) M, A, Q, or NP; and (2) MA, MQ, AQ, or NP based on Cognitive Preference Examination II (CPE-II) (Atwood, 1971) scores. Students were also classified as E or I, S or N, T or F, and J or P based on Myers-Briggs Type Indicator (MBTI) (Myers, 1962) scores. These data were then analyzed using chi-square calculations and one-way analysis of variance.

Results and Conclusions

A. The cognitive preference results classified 278 students into the following groups based on:

   1. a single preference: M-14 (5.0%), A-34 (12.3%), Q-10 (3.5%), and NP-220 (79.1%); and
   2. two preferences: MA-12 (40.3%), MQ-58 (20.8%), AQ-60 (21.6%), and NP-48 (17.3%).

B. The MBTI results classified 271 students into the following groups:

E	-	153	(56.5%)	or	I	- 118	(43.5%)
S	-	174	(64.2%)	or	N	- 97	(35.8%)
T	-	88	(33.6%)	or	F	- 180	(66.4%)
J	-	99	(36.5%)	or	P	- 172	(63.5%)

C. The chi-square values obtained were not statistically significant at $p \leq .05$, indicating that for the students in this study:

   1. cognitive preference orientation and MBTI personality types are independent variables. MBTI personality types do not necessarily influence an inquiry or traditional approach to learning in science.

   2. Males and females do not differ significantly from each other on measures of cognitive preference and MBTI personality types.

D. Statistically significant differences in intelligence were found:

   1. between sensing and intuitive students, in favor of intuitives; and between judging and perceiving students, in favor of perceiving types ($p \leq .001$); and

   2. when students were classified according to a single, definable cognitive preference such that M < Q and M < A ($p \leq .05$).

The predicted relationships that I, N, T, and P MBTI personality types would exhibit an inquiry cognitive preference orientation (A, Q, or AQ) and that E, S, F, and J MBTI personality types would exhibit a traditional cognitive preference orientation (M, MA, or MQ) were not supported by the analyses in this study. However, it is suggested that this relationship be explored using other personality inventories.

It is further suggested that additional studies are needed to clarify the relationship between intelligence and the measures in this study. Finally, it is recommended that investigations be designed to critically analyze students who do not exhibit a definable cognitive preference orientation (NP), since these students may represent the majority in most science classrooms. These students may be the most influenced toward inquiry or traditonal learning approaches by new science curricula and teaching behaviors. Consistencies/ inconsistencies of data in this study with published data will be presented during the formal presentation.

REFERENCES

Atwood, Ronald K. "Development of a Cognitive Preference Examination Utilizing General Science and Social Science Content." Journal of Research in Science Teaching, 1971, 8: 173-175.

Heath, Robert W. "Curriculum Cognition and Educational Measurement." Educational and Psychological Measurement, 1964, 34: 239-253.

Myers, Isabel Briggs. Manual: The Myers-Briggs Type Indicator. Palo Alto, California: Consulting Psychologists Press, 1962, 1975

Williams, Clive. "A Study of Cognitive Preferences." The Journal of Experimental Education, 1975, 43: 61-78.

Session J-1

LEARNING FROM SCIENCE TEXT AIDED BY DIAGNOSTIC AND PRESCRIPTIVE STRATEGIES DERIVED FROM INFORMATION-PROCESSING THEORY

Pierce Farragher
The Academy of Natural Sciences
Philadelphia, Pennsylvania 19131

Michael Szabo
The Pennsylvania State University
University Park, Pennsylvania 16802

Learning from text aided by information-processing techniques of embedded questions and increasingly complex prescriptive feedback was examined relative to achievement, time-on-task, and efficiency. Undergraduates (n=150) were randomly assigned to one of five treatments which varied along a feedback complexity range. After pre-testing, Ss completed a self-paced test unit on soil ecology, followed by a post-test and delayed retention test.

Significant differences in instructional time and learning efficiency were observed which were not linearly related to feedback complexity. Between group and achievement differences were marginally significant.

Knowledge of human information processing and/or how to apply it to learning from text requires further refinement.

Session J-2

A COMPARISON OF PUPIL CONTROL IDEOLOGY OF SCIENCE AND NON-SCIENCE SECONDARY STUDENT TEACHERS

Dan R. Jones
Illinois University at Carbondale
Carbondale, Illinois 62901

Purpose

The paper examines data on pupil control ideology (PCI) from two separate research studies involving secondary student teachers. A comparison is made of the results of the studies contrasting two student teaching populations: Eight-weeks science (SCI) and sixteen-weeks non-science (N-SCI). Three questions are addressed to the data from the studies:

1. Do secondary science teachers differ in PCI from student teachers in other secondary subject areas?
2. Does a shorter field experience for secondary science student teachers yield a different PCI than that observed in longer experience for non-science student teachers?
3. Does a difference in PCI exist within or between the groups on the variable of sex?

Procedure

Two separate studies were completed in which the pupil control ideology of secondary student teachers was measured before and at the end of their field experience. The extent to which a teacher is "custodial" or "humanistic" in their pupil control ideology is measured by the "Pupil Control Ideology Form" in which a numerical score is produced by responses to twenty items on a Likert-type scale--the higher the score, the more custodial the individual's pupil control ideology. Selected demographic data for sex, age, college major, and subject student taught were also gathered.

The two groups (SCI, N=19; N-SCI, N=22) differed in subject area taught and length of student teaching. The means of Pre-PCI for both groups were contrasted with a t-test for unmatched groups to determine equivalency of PCI prior to student teaching. T-tests comparisons between Post-PCI means were calculated to address the three research questions of this paper.

Results

The Pre-PCI means between groups was not significant, indicating equivalent pupil control ideology between groups prior to student teaching. A t-test for non-independent samples found no significant differences between Pre-PCI and Post-PCI means of either group, although the means of both increased from the pre- to post-measures (more custodial). The magnitude of

increase was greater for the N-SCI (+5.00) than for SCI (+1.58). A t-test for unmatched groups found the difference between Post-PCI means for the two groups to be non-significant. However, the difference between group means increased from +0.27 on Pre-PCI to +3.69 on Post-PCI. The Post-PCI of N-SCI females was significantly higher (more custodial) than the Post-PCI of SCI females ($p \leq .05$) No other contrast of sex was significant.

Conclusions

1. The populations of science and non-science secondary student teachers were equivalent in pupil control ideology prior to student teaching.
2. An effect of student teaching on each group was an increase in PCI which indicated a more custodial ideology being adopted after student teaching. This increase, although not significant, was consistent with the direction of change in PCI observed by other studies.
3. The longer experience for N-SCI student teachers appeared to influence the extent of PCI shift toward a more custodial idology.
4. Science student teachers do not become significantly different in pupil control ideology than student teachers in other subject areas even though the former are involved in field experiences only half as long.
5. Female non-science student teachers are significantly more custodial after student teaching twice as long than their science counterparts.
6. The comparison of groups raises the possibility that pupil control ideology may be influenced more by the length of student teaching than by the subject area taught.

Session J-2

THE EFFECTS OF A ONE-DAY ENERGY WORKSHOP ON SCIENCE TEACHERS' ATTITUDES TOWARD ENERGY-RELATED TOPICS

David L. Dunlop
University of Pittsburgh at Johnstown
Johnstown, Pennsylvania 15904

Frank Fazio
Indiana University of Pennsylvania
Indiana, Pennsylvania 15701

Purpose

The purpose of this study was to examine the effects of a one-day Department of Energy-sponsored workshop on the energy conservation attitudes of four groups of science teachers (K-8).

Procedures

In November of 1979, four one-day workshops were conducted for approximately 60 elementary and junior high science teachers. Each workshop was designed to provide the teachers with a comprehensive base of information in the area of energy resources and energy education. In addition, the participants were provided with methods, materials, and activities that could easily be adapted to their individual needs.

Each workshop included mini-lectures, slide presentations, discussions, demonstrations, and hands-on activities. Several educational games, computer activities, and projects were introduced and utilized by the participants.

A 24-item Likert-type instrument was administered as the initial and terminal activity of each workshop. The statements on the instrument were categorized into three sub-groups as follows: (1) Business/Industry; (2) Government; and (3) Personal/Individual.

In addition to an overall analysis, each sub-group was analyzed separately to determine its effects on the overall results. Further, two of the Likert statements were analyzed individually.

Results

Significant ($p \leq .05$) changes in the overall pre/post scores occurred in every instance, and similar shifts occurred in 92% of the sub-scores. Positive, but not significant, shifts occurred in the two items analyzed individually.

Conclusions

A one-day workshop, properly conducted, is a viable means of achieving "positive" shifts in attitudes toward energy-related topics. Attitudes toward three segments of society (business/industry, government, and personal/individual) appear to shift in a similar manner, hence, it does not appear that one of these segments is more resistant to attitude shifts than another.

With good planning and minimal effort, education can make a difference in an individual's attitude toward energy conservation and result in a society better equipped to make intelligent decisions concerning energy-related problems

Session J-2

THE EFFECT OF REASONING WORKSHOPS ON THE TEACHING STRATEGIES OF SECONDARY SCIENCE TEACHERS

Anne Lombard
Universtity of Massachusetts
Amherst, Massachusetts 01003

This study was done to determine whether teachers who participated in Science Teaching and the Development of Reasoning workshops from 1978 through 1980 felt that they had utilized the ideas of the workshop in changing their teaching style and methods. The study also determined the nature and extent of changes made which were consistent with the intent and philosophy of the workshops and identified what factors the teachers perceived as either facilitating or hindering their ability to make changes.

Data from the following sources were collected and analyzed:

a. An evaluation questionnaire, developed and pre-tested by the researcher, sent to all secondary science teachers (approximately 200) who have participated in Science Teaching and the Development of Reasoning workshops exceeding three hours in length in New England;

b. Interviews with 20 secondary science teachers who responded to the questionnaire and indicated that they had used the ideas from the workshop in their classroom;

c. Telephone interviews with 20 secondary science teachers who did not return the questionnaire to assess their attitudes and use of the workshop ideas;

d. The Stages of Concern Questionnaire administered to 21 participants of a 15 hour course, assessing changes in concerns and perceptions of changes in teaching behaviors as a result of the course, Science Teaching and the Development of Reasoning; and

e. Teacher-prepared materials such as tests, laboratory outlines, and review questions that illustrate the effects of the workshop on teaching.

These data revealed three levels of positive response to the workshop in 75% of those who responded:

a. An increased awareness of reasoning levels of students and the reasoning requirements of texts and tests, and an interest in translating this awareness into classroom changes;

b. Actual curriculum changes; and

c. Understanding the rationale for changes which had already been made.

Changes consistent with the intent and philosophy of the workshop occurred in the introduction of new topics and the presentation of concepts, in laboratory design and procedure, in testing and evaluation, and in use of the textbook, were reported by the responding teachers.

The teachers perceived the following factors as important in facilitating or hindering their ability to make changes related to this workshop in the classroom:

a. Agreement with the content and theoretical basis of the workshop;

b. Time during and after the workshop to assimilate the concepts presented;

c. Voluntary attendance; and

d. Administrative and colleague support.

The Stages of Concern Questionnaire revealed high "informational" and "personal" concerns for the new users of the workshop ideas.

Session J-4

THE EFFECT OF AN EXPLAINING MODULE ON PRESERVICE ELEMENTARY SCIENCE TEACHERS' KNOWLEDGE OF EXPLAINING TEACHING BEHAVIOR AND STUDENT ACHIEVEMENT

Joseph P. Riley II
University of Georgia
Athens, Georgia 30602

The objectives of this study are to:

1. Determine the effects of an explaining skills module on preservice science teachers' explaining knowledge, instructional behavior, and subsequent student achievement.
2. Identify relationships among teacher logical thinking skills, explaining skills, instructional behaviors, and student achievement.

Previous research on explaining has had varying degrees of success in improving teacher explanation, and associating this improvement with student achievement. This study draws from this previous research and extends it by investigating relationships among teacher logical thinking skill, explaining skill, instructional behavior, and student achievement.

Methodology and Design

Thirty-two preservice teachers were randomly assigned to a treatment or control group. The treatment group received instruction in explaining using the Miltz's program (1972). A post-test measuring knowledge of explaining was administered after the training was completed. Following the treatment, all teachers were required to teach a fifteen minute video-taped lesson to a small group of randomly selected elementary students. Student achievement scores and teacher instructional behavior were used as criterion measures.

The research design is:

$$R \quad O_1 \quad X_1 \quad O_2 \quad O_3 \quad O_4$$
$$R \quad O_1 \quad X_2 \quad O_2 \quad O_3 \quad O_4$$

where:

O_1 = Test of Logical Thinking (Topin and Capie, in press);

O_2 = Test of Explaining Knowledge (Pool and Capie, 1977);

O_3 = Teacher Performance Assessment Instrument (Capie, Anderson, Johnson and Ellett, 1979);

O_4 = Student Achievement Measure.

and

X_1 = treatment

X_2 = control

Analysis of variance was used to analyze treatment differences. Regression analysis was employed to establish relationships among criterion variables.

Results and Implications

The results of this study indicate that the explaining module used as the treatment successfully increased teacher knowledge about explaining. No significant differences could be found between the treatment and control teachers' instructional behavior in terms of explaining. The study was unable to identify differences in student achievement attributable to either treatment or teachers' logical thinking skills. Significant relationships were identified linking student achievement with several teacher competencies. Evidence that teaching strategies acquired in the college classroom are not being applied or utilized in the classroom has important implications for science educators interested in evaluating and improving their teacher education programs. Identification of teaching competencies highly related to student achievement provides a strong argument for including these skills in science education programs.

REFERENCES

Capie, W., Anderson, S. J., Johnson, C. E., and Ellett, C. D. "Teacher Performance Assessment Instrument." College of Education, University of Georgia, Athens, Georgia 1979.

Miltz, R. J. "Development and Evaluation of a Manual for Improving Teachers' Explanations." Technical Report No. 26. Stanford: Stanford University Center for Research and Development in Teaching, 1972.

Pool, K. W. and Capie, W. "The Miltz (1971) How-To-Explain Program and its Effects on Preservice Elementary Teacher Explaining Ability." Paper presented at the annual meeting of the American Educational Research Association, New York, 1977.

Tobin, K. and Capie, W. "Development and Validation of a Test of Logical Thinking." Journal of Educational and Psychological Measurement. (in press)

Session J-4

AN EMPIRICAL DETERMINATION OF CONCEPTS CONTRIBUTING TO SUCCESSFUL SCIENCE TASK PERFORMANCE: A STUDY OF MINERAL CLASSIFICATION

William L. Yarroch
Fred N. Finley
University of Wisconsin
Madison, Wisconsin 53706

It is important for teachers to know what students understand in a particular content domain before they can plan instruction to build on their student's prior knowledge. It is also important to know how specific knowledge affects the performance of related task and problem solving ability. One aspect of this relationship between student conceptual knowledge in a particular content domain and the ability of the student to use that knowledge to perform a classification task is examinied. This study was designed to provide information as to which relevant conceptual knowledge contributes to student success in performing the required mineral identification task.

After regular classroom instruction on mineral identification, 35 randomly selected students were tested, through interview, with respect to their knowledge of relevant concepts and their ability to perform mineral classification. The concepts students were taught and expected to use were mineral names and the mineral properties (luster, hardness, cleavage, color, and streak) and the logical class rule that was applied if one followed the classification scheme.

Tape recordings of the interviews were translated into numerical data with high (96%) interrater reliability. Student knowledge of the five mineral property concepts and the logical class rule were used as predictor variables for the dependent variable, mineral name. The method of all possible regressions and the Cp selection criterion was used to reduce the independent variables to a best set of predictions of student success. After reductions, four variables (hardness, cleavage, luster, and streak) accounted for 61% of the variance. Post hoc analysis showed two of these variables, hardness and cleavage, to have partial regression coefficients statistically significant from zero.

The results of the study indicated that the students' knowledge of the concepts used to describe minerals was extremely important in predicting their success at classifying minerals. More specifically, it appears that earth science teachers should emphasize the concepts of hardness and cleavage in teaching mineral classification. In a more general sense, the findings suggest that science teachers interested in having students learn to perform science tasks need to be cognizant of the importance of the relevant student conceptual knowledge.

Session K-1

TACTILE APPREHENSION IN YOUNG CHILDREN--DEVELOPMENT AND IMPLICATIONS FOR DESIGN OF SCIENCE CURRICULA

Dennis W. Sunal
Cynthia S. Sunal
West Virginia University
Morgantown, West Virginia 26505

The purposes of this study were to measure and describe the development of tactile apprehension as it pertains to science curriculum considerations among children ages three through six. This involved investigation of the nature, prediction, and curriculum implications of the sense of touch in the area of textural discrimination.

One hundred and twenty-eight children, aged 32 to 83 months, were subjects in a study investigating tactile perception of textures with these characteristics: rough, smooth, soft, and hard. The subjects were randomly selected as follows: 50 from a small West Virginia town, 53 from a suburban early childhood center in Maryland, and 25 from an urban college laboratory school in Maryland. Each of the three groups was racially mixed, averaging 73% white, 25% back, and 2% Asian-American.

Each child was tested with the Textural Discrimination Task. The Task contained stimulus objects consisting of four pillows and four blocks varied in the dimensions of roughness and softness: (1) soft and smooth were represented by two satin-covered, fiber-filled pillows; (2) rough and soft by two burlap webbing pillows; (3) hard and rough by two sand-covered wooden blocks; and (4) smooth and hard by two plastic blocks.

Each child was asked to investigate a box. Then it was set on a table and children were told they would be playing two games, one a touching and feeling game, the other a seeing game. An item was placed in the box by the investigator. The child was asked to reach in, feel the item, and was encouraged to describe its texture. If the child named the item or described it, the response (s) were recorded. This procedure was repeated with all eight items.

In Part II, the box was removed and the investigator laid each item one at a time on the table. The child was asked to identify the textures of the objects visually as they were presented with no tactile involvement. Part I's procedure for recording responses was followed.

Results were analyzed using analysis of variance, multiple regression, and analysis of covariance. These analyses demonstrated: (1) regular growth and also a developmental sequence in tactile apprehension of textures between two to seven years of age with significant change ocurring over a 15.7 month interval; (2) the ability to predict children's level of developmental growth and the characteristics of their verbal responses using significant regression equations; (3) that naming the item, rather than describing its textural characteristics, occurs less frequently as age increases and is related to the

sex of the child; (4) that sex is not a significant factor in determining tactile apprehension of textures in the sample studied; and (5) significant differences occurred in the identification of textures by touch versus sight. Within the sample investigated, the above findings support the concept of a developmental sequence and a significant predictive relationship existing for textural apprehension which is significantly related to age. Neither sex nor background variables related to community setting were important factors in textural apprehension.

The research implies a sequence and structure of activities with children which will foster tactile apprehension to match their potential developmental level. Prediction of children's level of development in tactile apprehension of textures and of the characteristics of their verbal responses has implications for psychomotor and cognitive growth aspects of early childhood curriculum and instruction.

Session K-1

EVALUATING SCIENCE CURRICULA: RELATING EDUCATIONAL PROCESS TO PRODUCT

James D. Ellis
The University of Texas at Austin
Austin, Texas 78712

Research in education during the late 1970's included a new focus on the implementation phase of curriculum development. An increased awareness of the importance of including measures of the educational process in evaluation studies resulted from failures to find significant differences between traditionally defined experimental and control groups in large scale curriculum projects. The realization of the importance of planned implementation designs became apparent with the failure of nationally developed curricula to be used as intended by a large percentage of teachers.

The Research and Developmental Center in Austin, Texas has devoted extensive efforts to the development and use of the Concerns Based Adoption Model of Implementation. The Stages of Concern and Levels of Use (LoU) instruments have been used successfully to provide formative information for the improvement of implementation efforts.

During the development and implementation phase of curriculum evaluation often teachers and districts go through a process of adapting to the innovation. Program objectives are often modified, or teaching processes changed in response to informal and formal feedback from teachers and students. The success of the implementation phase would be enhanced by use of a quality formative evaluation design which would include appropriate information for making modification decisions. The LoU instrument provides a very effective model for explaining the teacher's adaption to the innovation. Including information on configuration of use in the LoU interview increases its utility as a measure of the actual teaching process. The LoU interview with a complete configuration of use is a good formative evaluation tool.

When the purpose of the evaluation is to determine the degree to which a curriculum implementation has been successful at achieving predetermined objectives, the fidelity approach is the valid and appropriate procedure to use. Curricular programs with predetermined objectives are the result of national, state, regional, and occasionally district efforts to provide instruction to meet the needs of the citizens served. These programs are adopted for use in individual classrooms within districts and often diverse variations of use can occur. When evaluating overall effectiveness of the program at achieving the predetermined objectives, it is important to document all variations of use and additional outcomes; but, the central focus should be on the process outlined by the curriculum.

Session K-1

PATTERNS IN THE USE OF ELEMENTARY SCHOOL SCIENCE PROGRAM MATERIALS: AN OBSERVATIONAL STUDY

Charles W. Anderson
Michigan State University
East Lansing, Michigan 48824

Modern elementary school science programs as implemented in the classroom are often very different from the programs that are described in the teachers' guides. The modifications that teachers make in program materials are not simply "error variance." They are understandable and to some extent predictable. Understanding and prediction must be based, however, on direct observation and analysis of the relationship between the "curriculum as described in the program materials" and the "curriculum as practiced in the classroom." This is the purpose of this study.

Each of the teachers was observed using the science program that he or she normally used (teachers were observed using five different commerical science programs). In addition, nine of the ten teachers were observed as they taught with energy-education materials developed by the National Science Teachers Association and by the Science and Mathematics Teaching Center at Michigan State University. Each teacher was observed teaching five science lessons; thus, a total of 50 lessons were observed.

Data collection involved both classroom observation of science lessons and analysis of science program materials. Observation and analysis procedures produced both narrative descriptions and coded data, and they made possible a direct comparison between the science programs as described in the teachers' guides and the science programs as practiced in the classrooms.

Data analysis procedures made use of a modified case-study approach. Narratives were read by two independent readers. Hypotheses were formed by the readers and supported by documented references to events in the narratives or program materials analyses. These hypotheses were then tested and modified in a three step process.

Results included the following:

1. Science program materials do make a difference. Most of the observed teachers depended on prepared program materials, and the materials exerted a great influence on both the form and content of the teachers' behavior.
2. Teachers invariably modified the materials as they used them in their classrooms. Reasons for modifications included the need to accommodate science teaching to the teachers' classroom routines, simplification of the materials due to time pressure or other factors, and the desire to elaborate on or enrich certain parts of the programs.

Both the methodology and the results of this study are potentially useful. The methods used in this study make possible a more direct analysis of the nature of teachers' decisions as they use science program materials than is possible using other methods. The results of this study can aid in a process of "mutual accommodation," in which teachers are adequately prepared to use elementary school science curriculum materials, and the materials are designed with a realistic understanding of the needs of both the teachers and their students.

Session K-2

RELATIONSHIP BETWEEN LOCUS OF CONTROL AND THE DEVELOPMENT OF SPATIAL CONCEPTUAL ABILITIES

Herbert G. Cohen
Arizona State University
Tempe, Arizona 85281

The primary purpose of this investigation was the examination of the hypothesis that a child who exhibits internalness on a locus of control continuum will interact with science manipulatives to a higher degree than a child exhibiting externalness, and that this higher degree of interaction will lead to a greater development of spatial conceptual abilities as well as a greater acquisition of science process abilities. Research has lent some support to the latter notion (Rowe, 1979; Saunders and Yeany, 1979; and Dost and Yeany, 1979), although the relationship between locus of control and the development of spatial conceptual abilities has not been examined. Another variable studied was whether or not access to manipulatives promoted a greater degree of change along the internal-external continuum towards internalness than no exposure to manipulatives.

Procedure

The Nowicki-Strickland Locus of Control Measure for Children (1973) was administered to fifth-grade students attending a suburban school in Maricopa County, Arizona. Pairs of subjects were generated from a rank-order list. The pairing procedure was accomplished by associating a subject with another subject whose score on the locus of control measure was equal to the first subject's score, or either slightly above or below that subject's score. This yielded 26 subject-pairs. One member of each pair was randomly selected and placed in the experimental group, while the other subject was placed in the control group.

Treatment and locus of control were the independent variables. The basic design was post-test only control group design.

The experimental group's instruction consisted of use of SCIIS materials (Thier, et al. 1978)--Parts II, III, IV, and V. The student's use of materials was highly individualized, being student-centered. The control group's instruction was centered on the textbook, Learning Science (Renner, Stafford, and Coulter, 1977)--chapters 7, 8, 9, 10, and 11, and was teacher directed, the focus being on written rather than manipulative exercises.

Six Piagetian-type tasks (Cohen, 1978; Doyle, 1980) were used to assess acquisition of science process skills. The Nowicki-Strickland Locus of Control Measure for Children was readministered at the end of the instructional period.

Results

The results of a chi-square procedure for two independent samples with correction for continuity indicated that there was a significant difference on performance on the Piagetian-type tasks between the internal subgroup and the external subgroup ($p \leq .05$).

The results of another analysis using the above chi-square procedure indicated that there was a significant difference on performance on the Piagetian-type tasks between the external, experimental subgroup and the external, control subgroup; and between the internal, experimental subgroup and the internal, control subgroup ($p \leq .05$).

Using a t-test for two independent samples, no significant difference in performance was detected on the TSPT between the internal and external subgroups.

A t-test for matched pairs was used to determine whether changes in locus of control had occurred between the groups. The results of this analysis were significant ($p \leq .05$).

Also, regardless of an individual's internalness/externalness, access to manipulatives was beneficial with respect to movement along the internal-external continuum towards internalness.

REFFERENCES

Cohen, H. "The Scaling of Six Topological Piagetian Groupings as well as the Effect that Certain Selected Variables have on the Attainment of these Groupings and Some of their Homologues in the Logical Domain." Journal of Research in Science Teaching, 1978, 15 (2): 115-125

Dost, R. and Yeany, R. "The Effects of Diagnosis, Remediation and Locus of Control in Different Levels of Science Achievement in University Students." Paper presented at the National Association for Research in Science Teaching, Atlanta, Georgia, 1979.

Doyle, J. "The Order of Attainment of Eight Projective Groupings: An Analysis of Piaget's Spatial Model." Journal of Research in Science Teaching, 1980, 17 (1): 55-58.

Ludeman, R., Fyffe, D., Robinson, R., McLeod, R. and Berkheimer, G. The Science Process Test, Form D. Developed at the Science and Mathematics Teaching Center, Michigan State University.

Nowicki, S. and Strickland, B. "A Locus of Control Scale for Children." Journal of Consulting and Clinical Psychology, 1973, 40 (1): 148-154.

Rowe, M. B., "Science and Fate Control: Its Implication for Instructional Planning." Paper presented at the Annual Meeting of the National Science Teachers Association, Atlanta, Georgia, 1979.

Saunders, R. and Yeany, R. "The Effects of Diagnosis, Remediation, and Locus of Control on Achievement, Retention and Attitudes of Middle School Science Students." Paper presented at Annual Meeting of the National Association for Research in Science Teaching. Atlanta, Georgia, 1979.

Renner, J., Stafford, D., and Coulter, V. Learning Science. Enseno, California: Glenco (McMillan), 1977.

Thier, H., Karplus, R., Lawson, C., Knott, R., and Montgomery, M. SCIIS. Chicago, Ill.: Rand McNally, 1978.

Session K-2

VISUAL TESTING AND VISUAL INSTRUCTION IN HIGH SCHOOL BIOLOGY

Michael Szabo
Francis Dwyer
The Pennsylvania State University
University Park, Pennsylvania 16802

Hermes T. DeMelo
Federal University of Bahia
Salvador, Bahia Brazil

Purpose

The purpose of this study was to empirically investigate the effectiveness of (1) visual instruction composed of single line drawings and printed words as compared to printed-words-only instruction; (2) visual tests; and (3) the interaction between mode of instruction (visual and non-visual) and mode of testing (visual and non-visual).

Procedures

Ninety-six first-year biology students from a Central Pennsylvania high school system were the subjects of this study. After being randomly assigned to either an experimental (visual instruction) or control (non-visual instruction) group, they received either a visual or non-visual version of an instructional unit designed to teach anatomy and physiology of the human heart.

Twenty-four hours later, half of the students (N=24) in the experimental group received a non-visual test and in the other half (N=24) a visual version of the same test. This testing procedure was repeated for the control group following a 2x2 post-test-only factoral design.

A drawing test was also completed by all subjects in both experimental (N=48) and control (N=48) groups.

Analyses of variance and a t-test were performed with the obtained data.

Results

The findings of this study indicate that the visual version of the instructional unit on the human heart used in this study affected the performance of the students significantly in the drawing test and in each subscale (identification, terminology, and comprehension) as well as in the composite score of both visual and non-visual versions of the achievement tests. Due to the high correlation pattern among scores of the subscales in both the visual and paper-pencil tests, this study does not warrant the conclusion that four separate and distinct effects were present. Furthermore, the reliabilities of the terminology and comprehension subscales were not sufficiently high in this study.

The data did not support any main effect of mode of testing on the performance of the subjects in any of the subscales or in the composite scores of both visual and non-visual versions of the tests used in this study.

The interaction between mode of instruction and mode of testing was revealed for the identification subscale. Subjects who completed the visual instruction scored higher on the visual test than the subjects who completed the same visual instruction scored on the paper pencil version of the test on subscale identification. It was also found that the students who completed the visual instruction scored higher on the visual test than the students who completed the non-visual version of the test on the same subscale identification. Finally, the students who completed the visual instruction scored higher on the visual test than the students who completed the non-visual instruction with the visual version of the achievement test on the identification subscale.

Session K-2

COMPARISION OF HIGH AND LOW SPATIAL MALES AND FEMALES ON SELECTED SCIENCE CONCEPTS

Carole Ann Camp
University of Massachusetts
Amherst, Massachusetts 01003

The purpose of this study was to investigage patterns of similarities and differences between and among groups of students who had been grouped by spatial ability and gender. The overall problem is that there are striking differences between males and females in their ability to do spatial tasks and at some levels, in their achievement. A possible subset of this problem is the fact that females are not considering and entering the fields of science and engineering at the same rate as males.

The clinical interview was selected for this study to uncover dimensions of the cognitive processes not capturable by most standardized methods of measurement.

The population selected for this study consisted of ninth-grade students in a junior high school. One hundred and two students who were enrolled in four physical science classes were given the Differential Aptitude Test (DAT) Spatial Relations Subtest (Bennett, Seashore, and Wesman, 1959) by their classroom teacher. The assumption is that the 102 students in this original population represent all the students who normally study science in the ninth-grade in this school and are also representative of a cross section of abilities, interests, and socio-economic groups, and have varied interests in science.

This population of students was divided into six groups based on performance on the DAT. The scores for males and females were rank-ordered separately and divided into even thirds. This gave two groups each, one male and one female, for high, medium, and low scorers. The middle scorers were then eliminated from the study in order to create groups consisting of students at extreme levels of spatial ability. Four pools of students were thus created: (1) high scoring males (HSM); (2) low scoring males (LSM); (3) high scoring females (HSF); and (4) low scoring females (LSF). Ten students were randomly selected from each of these four groups and asked to participate in the study . However, even though the total pool of low-scoring males (LSM) was invited to participate, only six boys choose to do so. It was decided to have this group remain at six members rather than including males with higher scores in the group.

The students were then interviewed twice. Each student was asked to repeat two items from the DAT during the first interview. In addition, the Karplus (1977) volume displacement task was included in this session since males and females appear to differ on this concept.

Two science problems were selected for the second interview, one on concepts related to the earth-moon-sun system and the second on relative motion. The audio transcription of each session, together with the students'

drawings and the researcher's observations, were collected and collated for each student.

Certain areas of interest emerged upon analysis of the data. The following then is a brief selected outline of some of the findings. High spatial students tended to rotate the items from the Spatial Test, and LSF could not. More females than males folded the item incorrectly. Sixty percent of the LSF were Pre-Corpernican, that is, they had a geocentric model of the universe. Many of the LSF could not "see" the plane of the moon's orbit as different from the plane of the paper on which it was drawn. The diagrams of the earth-moon-sun system drawn by some students included earth co-ordinates, i.e., N,S,E,W. Both high scoring and low scoring males and females thought that the earth's shadow caused the phases of the moon. Many had no idea about what mechanism caused the moon to shine.

All of the males did the volume displacement puzzle correctly, but only one female in the LSF group correctly interpreted the puzzle. Ninety percent of the HSM shifted planes when diagramming the moon and earth from a point on the moon's orbit; and only 35% high and low spatial females were able to correctly diagram this same arrangement.

The low scoring males exhibited behavior of a reluctant and non-participatory nature, raising the issue of whether the spatial test (DAT) did in fact identify males of low spatial ability.

The first and perhaps the most significant conclusion from this study is the great benefit to research in science education that is available through the mechanism of the clinical interview. Secondly, in spite of several problems in the design of this study, it would appear that there are many differences between and among the groups that were selected. These differences were evident both in spatial skills and abilities in science. These differences need to continually be researched in order that we may best meet the needs of high and low spatial students and males and females.

REFERENCES

Bennett, G. R., Seashore, and Wesman, A. G. Differential Aptitude Tests, Manual. (3rd Ed.). New York: Psychological Corp., 1959.

Karplus, R. et al. Science Teaching and the Development of Reasoning: A Workshop. Berkeley: Lawrence Hall of Science, University of California, 1977.

Session K-3

COLLEGE LEVEL PHYSICAL SCIENCE FOR NON-MAJORS

John P. Schellenberg
Paul E. Bell
Kutztown State College
Kutztown, Pennsylvania 19350

This research report focuses on an experimental study comparing two laboratory approaches to a college level physical science course for non-majors. An approach using contemporary topics was compared to an approach using standard topics. The three dependent variables were achievement of subject content, scientific attitude, and understanding the nature of science. The data analysis showed no significant difference between treatments.

The study used design features intended to control possible teacher effect. A treatment monitoring instrument used to measure congruence between intended and actual treatment proved to a very useful feature. It showed on a second trial of the experiment that one of the laboratory instructors did not follow the intended treatment. This was valuable to the investigator in the analysis of his data for that trial.

The investigator strongly recommends that such monitoring techniques be included in this type of experimental designs.

Session K-3

EFFECT OF EXPERIENCE WITH INVESTIGATIVE BIOLOGY ON COLLEGE STUDENTS' VIEWS OF SCIENTIFIC METHOD AND KNOWLEDGE

Margaret Waterman
Cornell University
Ithaca, New York 14850

The traditional concept of science with its emphasis on procedure and its description of the nature of scientific knowledge as discovered, true and unchanging, forms the basis of most teaching about science, scientific method, and scientific knowledge. This view, however, is inconsistent with what scientists actually do and with the fluid nature of scientific knowledge. In philosophy of science in the last fifty years there has been a redefinition of these traditional concepts of scientific method and scientific knowledge resulting in an understanding of science that more accurately reflects the "real thing."

Because this alternate view about knowledge is radically different from the traditional, the two views may be used to form a scale for studying people's notions of scientific method and scientific knowledge, and how those understandings change with experience with science. In this study, college biology students' views (of the nature of scientific knowledge) and how they come to be are described. A further goal was to detect any changes that may occur in these views as a result of participation in a heavily investigative biology laboratory course. A 32-item survey to assess students' views was devised, field tested, and revised. The items were written to reflect either traditional or reformulated views of science. The instrument consists of 12 statements on beliefs about knowledge and 20 statements on theory formulation, objectivity of science, or the nature of truth in science.

The survey was given to approximately 550 students enrolled in the biology course at the start of the course, and again at either midsemester or at the end of one semester. In addition, a small group of freshman college students not enrolled in the course were surveyed. This second group was a control against changes in views about knowledge that may occur by virtue of being in college.

The results of the study are presented in two ways: (1) as patterns of responses observed in subgroups (detected by the technique of factor analysis), and (2) as responses to the individual items. Because a self-paired design was used, detection of changes in response patterns and individual item responses was possible.

Initial observations from pilot studies, the pre-test data, and from formative interviews indicate that at the start of the biology course students views are diverse and reflect aspects of both traditional and reformulated views of science. Comparison of responses of students at the beginning and end of the same course suggest that some students' notions about scientific method and knowledge change after experience with investigative science. This experience permits students to develop notions about science that more accurately reflect the reality of science, its fallibility and limitations.

Session K-3

OPERATIONAL DETERMINANTS FOR ACADEMIC PROMOTION IN UNDERGRADUATE SCIENCE DEPARTMENTS

Gloria J. Dyer
Fairleigh Dickinson University
Rutherford, New Jersery 07070

While teaching is of utmost concern to most institutions (Moomaw, 1977), institutions differ in their teaching emphasis. Some institutions are more heavily involved in research than others. In view of this difference in emphasis it would seem logical that faculty promotional criteria might be weighted differently in different institutions. The purpose of this study was to investigate this possibility by determining if similar promotional criteria were in operation in two separate institutions.

The universities examined in this research were large and metropolitan, one state supported and one private in another state. The biology, chemistry, geology, and physics departments of each were compared using the following criteria: (1) weighted publications; (2) number of publications; (3) citation counts; (4) external grants; (5) student evaluations; and (6) age (as an unskilled variable).

Publications were weighted by using the "impact factor" reported in Science Citation Index. The publication count was made using bibliographies which had been verified by faculty members in the sample. Citation counts were made from Science Citation Index. Grant amounts were obtained from official school publications such as Annual Reviews. The universal question, "How would you rate your instructor compared with other instructors?" was taken from student sponsored student evaluations. Age was obtained from such publications as American Men and Women in Science.

The sample consisted of 157 men and women who had been promoted in the past ten years. The criteria were studied for the five years prior to each promotion.

An analysis of variance by schools and by ranks was performed for each criterion. There were significant differences between schools for all criteria except student evaluations. Significant differences between ranks occurred for publication evaluations, number of publications, and age. An interaction between schools and ranks occurred in publication evaluations and number of publications. While assistant professors in both schools began with approximately equal publications there were large differences between the senior ranks at the state school where faculty published considerable more than at the private school. There were significant differences in age between ranks and between schools with the private school faculty being slightly older.

A high correlation (r=.93) was found between the total number of publications and publication evaluations. The more a person publishes the more prestigious the journals he publishes in.

Student evaluations differed little between ranks indicating that they were not factors in promotions. Moreover, there was very little difference in student evaluations between schools with faculty generally receiving good recommendations. There was no significant correlation between student evaluation and any of the other criteria (publications or grants).

The number of publications, the quality of journals, the citation count, and the amount of grants were not significantly different between ranks in the private school. However, there were large differences between assistant and associate ranks in all criteria (except student evaluations) in the state school. In addition, full professors published more than associates and were cited more frequently.

The data show that scholarly productivity in the form of publications and grants is a determinant for academic promotion in the state school while criteria other than those studied (such as administrative duties and service) may be operational in the private school.

REFERENCE

Moomaw, W. E. "Practice and Problems in Evaluating Instruction." New Directions for Higher Education, 1977 (spring), 17: 77-91.

Session K-4

VALIDATION OF THE TEST OF INTEGRATED SCIENCE PROCESS SKILLS

James R. Okey
Charles F. Porter
University of Georgia
Athens, Georgia 30602

F. Gerald Dillashaw
Bethany College
Bethany, West Virginia 26032

Introduction

Although science process skill achievement is an important part of secondary school science programs, few tests exist to measure these outcomes. To meet this need, the Test of Integrated Process Skills (TIPS) was developed. The TIPS test included assessment of five components of process skill achievement: identifying variables, operationally defining, stating hypotheses, designing investigations, and graphing-interpreting data. Content validity and reliability were demonstrated in a previous study.

The purpose of this study was to examine the concurrent validity and factor structure of the TIPS test. Concurrent validity was a concern because multiple-choice items are used to measure process skill achievement. Students select hypotheses, variables, and designs on the test rather than generate their own. Selecting responses is preferred because of the ease in administering and scoring the test. However, generating responses by students is the ultimate skill, and one needs to be sure that the easy way to measure performance (selecting) predicts the desired skill (generating).

The factor structure of the TIPS test was important to be sure that it assessed process skill performance. Factor analysis can be used to demonstrate whether a test measures one or more constructs.

Procedures

The construct validity portion of the study was conducted with three classes (N=59) of ninth-graders. The students first studied a two-week instructional unit on the science process skills. This was done to insure that a full range of performance levels would be evident.

For each outcome on the TIPS test, corresponding open response items were developed. The same process skills were represented on each test but the contexts and the methods of responding were different.

The students were divided into two groups; each group completed half of the TIPS items and their open response counterparts. The data from this group, therefore, consisted of responses to pairs of multiple-choice and open response items designed to test the same objectives.

The factor analysis study was conducted with students in grades 7-12 (N=656). The large sample was selected to represent the range of socio-economic levels and racial groups found in schools. The TIPS tests were administered by the classroom teachers. The data from this tryout consisted of responses to the 36-item TIPS test by the 656 students. A principle components factor analysis using the promax rotation was done.

Results

Concurrent validity was estimated by correlating scores on the multiple choice test of process skill ability with scores on the open response test. Two correlation coefficients were generated because only half the items were completed by any student. The coefficients were 0.859 and 0.763. The average correlation of a student's ability to select and generate process skill responses was, therefore, about 0.8.

The factor analysis of scores on the five TIPS subtests produced a one-factor solution. Factor loadings of the five subscales ranged from 0.68 to 0.75.

Conclusions

The concurrent validity of the TIPS test was strongly supported in this study. The easily administered and scored multiple-choice test is a strong predictor of performance in a situation where students have to generate their own variables, operational definitions, hypotheses, designs, and graphs.

The factor analysis supports the conclusion that the TIPS test is a cohesive measure of science process skill ability.

Session K-4

DESIGNING A LIKERT TYPE SCALE TO ASSESS ATTITUDE TOWARD ENERGY CONSERVATION

Thomas R. Koballa, Jr.
The Pennsylvania State University
University Park, Pennsylvania 16802

The purpose of the study was to design a reliable and valid instrument to measure the attitudes of teachers toward energy conservation.

A single dimension does not effectively represent an individual's attitude. It is the expression of personal preferences or beliefs, appearing directional rather than neutral. Attitudes expressing a personal preference can be represented by "I believe" statements as included by Zimbardo and Ebbesen (1969) as a component of the attitude construct. Sherif (1976) points out that attitudes are also social in nature, drawing significance from reference groups and personable others. Finally, attitudes have an action component (Shrigley and Trueblood, 1979). Using this rationale, an instrument attempting to measure teacher's attitudes toward energy conservation should arouse affective responses to statements that are (1) egocentric; (2) social-centric; and (3) action-centered in nature.

In designing the Likert-type scale the following goals were set;

1. A short scale of 20-25 statements requiring only 10-15 minutes to administer;
2. A representative sampling of positive and negative statements;
3. Statements meeting the 13 criteria developed by Edwards (1957);
4. Statements general enough that they might be used with any special segment of the population;
5. Statements that had at least an item-total correlation coefficent (adjusted) of .30 (a validity factor); and
6. A scale with a coefficient alpha of at least .80.

The present 22 item scale is the result of several generations of administrating to preservice elementary teachers and submitting to Likert Item Analysis. Most statements not reaching the item total correlation coefficent r-value of .30 were either revised or dropped. The scale was kept relevant to the psychological object by reference to energy conservation in each statement.

As a means of further validation of the attitude statements, the data collected from 102 preservice elementary teachers were subjected to a principle components factor analysis as a means of categorizing items into subscales that could be used to identify specific characteristics of respondent's attitude toward energy conservation. A varimax rotation using the three factor solution resulted in items loading on each of the three factors labeled egocentric, sociocentric, and action-centered. Table I provides an example statement from each of the three subscales, when combined constituting a 15 statement scale. Table II presents summary statistical information.

Table I

Example Statements

		Factor Loading			Adj Item Total Correlation	
		I	II	III	Total Scale	Subscales Combined
5.	I am personally not in favor of energy conservation. N	.81	.03	-.21	.62	.74
17.	The need to conserve energy does not exist. N	.01	-.64	.02	.50	.62
6.	The schools should tool up immediately to teach practices of energy conservation. P	.34	.13	.61	.46	.56

Table II

Statistical Information
(n=102)

	Total Scale	Subscales Combined
Mean	81.77	60.17
Standard Deviation	8.26	5.62
Average Inter-Item Correlation	.17	.18
Coefficient Alpha	.82	.77

It is recommended that the 22 statement version be used as a single scale or that a combination of the three subscales into a single scale of 15 statements be used by the researcher as a shorter scale, and one testing the three specific components of attitude illustrated in the factor analysis.

REFERENCES

Edwards, A. L. Techiniques of Attitude Scale Construction. New York: Appleton-Centrury-Crofts, 1957.

Sherif, C. W. Orientation to Social Psychology. New York: Harper and Row, 1976.

Shrigley, R. L. and Trueblood, C. R. "Designing a Likert-type Scale to Assess Attitude Toward Metrication." Journal of Research in Science Teaching, 1979, 16: 73-78.

Zinbardo, P. and Ebbesen, E. B. Influencing Attitudes and Changing Behavior. Reading, Mass.: Addison-Wesley Publishing Co., 1969.

Session K-5

ASSESSING PUPIL ENGAGEMENT IN LEARNING ACTIVITIES

William Capie
Kenneth G. Tobin
University of Georgia
Athens, Georgia 30602

This session will enable participants to explore a rationale for using pupil engagement in learning activities as a variable in studies of classroom processes. Engagement categories will be presented as a means of partitioning activity according to particular relevance to the desired outcomes. Activities will include developing a preliminary assessment system, using an existing system to gather data, using a model to plan data gathering activities, and evaluating alternative analysis involving engagement data.

Session L-1

A STUDY OF THE PERCEPTUAL ORIENTATION OF COMMUNITY COLLEGE STUDENTS AND THEIR ATTITUDES TOWARD SCIENCE AS THEY RELATE TO SCIENCE ACHIEVEMENT

Linda W. Crow
Houston Community College
Houston, Texas 77007

Martha K. Piper
University of Houston
Houston, Texas 77004

Community Colleges serve a diversity of students. Some of these students continue their education in four-year institutions and select science as their career choice. McKenney and Keen (1977) found among graduate business majors that the perceptual orientation (field-dependence-independence) affected whether students chose careers involving analytical skills such as the mathematics and science or socially oriented skills such as social sciences. Segal, Campbell and Herskovits (1966) indicated that the way students perceive the world has a tremendous effect on how they do in any setting. Recently, Shymansky and Yore (1980) have reported that students who are field independent achieve higher in science when exposed to certain types of discovery strategies. There have also been studies to indicate a relationship between attitudes and science achievement. If these generalizations hold true, it is logical to believe that students who are field independent choose science as a major and have positive attitudes toward science. It would also follow, then, that both field independence and positive attitudes affect science achievement.

Perceptual orientation has been studied extensively with young students (high school age and younger). There are relatively few studies involving community college students even though students at community colleges are required generally to take a minimum of six hours of science. As this group represents a potential pool of science majors, it is vital to begin to explore the characteristics of community college students enrolled in science classes.

The purpose of this study is to investigate the perceptual orientation and attitudes toward science of community college students and the relationship of these characteristics toward science achievement.

Hypotheses

1. Students who are field independent also have a positive attitude toward science when compared with students who are field dependent.
2. Students who are field independent and have a positive attidude toward science achieve significantly higher on test scores than students who are field dependent.

Methodology

The population for this study are 87 community college students enrolled in four freshman science courses taught in a traditional lecture mode. The community college has open admissions located in an urban metropolitan area.

During the semester each student was given the Group Embedded Figures Test (Witkin, et al., 1971) and the inventory of Scientific Attitudes (Moore and Sutman, 1970). At the end of the semester each student was given a final written exam.

Instruments

1. Group Embedded FiguresTest (Witkin, et al., 1971) was used to determine the students' perceptual orientation.
2. The Inventory of Scientific Attitudes (Moore and Sutman, 1970) was used to determine the students' attitudes toward science.
3. A final exam was given and the grade used to assess the students' science achievement.

Analysis of Data

For hypothesis one, a Pearson correlation will be used to analyze the data. A two way ANOVA will be used to analyzed the data for hypothesis two.

Results

The results of these analysis will be discussed during the presentation.

REFERENCES

McKenney, James L., and Keen, Peter G. W. "How Managers' Minds Work." Harvard Business Review, 1977, 52: 44-48.

Moore, Richard W., and Sutman, Frank X. "The Development, Field Test and Validation of an Inventory of Scientific Attitudes." Journal of Research in Science Teaching, 1970, 7: 85-94.

Segan, M. H., Campbell, D. T., and Herskovits, M. J. The Influence of Culture on Visual Perception. Indianapolis: Bobbs-Merrill, 1966.

Shymansky, James A. and Yore, Larry D. "A Study of Teaching Strategies, Student Cognitive Development, and Cognitive Style as They Relate to Student Achievement in Science." Journal of Research in Science Teaching, 1980, 17(s): 369-382.

Witkin, H. A., Oltman, P. K., Raskin, E., and Karp, S. A., Manual For Embedded Figures Test and Group Embedded Figures Test. Palto Alto: Consulting Psychologist Press, 1971.

Session L-1

DEVELOPING AN INSTRUMENT TO MEASURE SCIENTIFIC ATTITUDES

Carol Wareing
Tufts University
Medford, Massachusetts 02155

The goals of science teaching have historically centered about scientific knowledge or content, process skills, and attitude development.

Since Krathwohl et al. (1964) developed the taxonomy of the affective domain, attitudes and values regarding learning have received particular attention from educators.

Arthur Combs (1971) for example, emphasizes the significance of the affective dimension by stating that any educational system ignoring affect is making itself absolutely ineffective.

Science is not exempt from this premise. According to Newton (1975) greater attention from science educators to the perceptions of their students relative to science--its teachings and methodologies--is needed. He further contends that estimations of such perceptions are more often a matter of opinion or judgement based on attitudes than on empirical givens.

Problems emerging in the identification and measurement of such attitudes due to the paucity of reliable instruments (Kozlow and Nay, 1976) however, led the author to undertake the task of constructing and validating a Likert-type scale for measuring scientific attitudes of students in grades four through twelve.

Both the Summated Rating Scale Suggestions proffered by Likert (1932) and the Corey Scale Development Technique (Payne, 1974) were consulted for construction of the inventory.

Content validity of the instrument was determined according to the judgments of a nineteen-member panel of scientists and science educators. The instrument draft, containing 79 items, was pilot-tested with a target group of 204 younsters while the final instrument of 50 items was administered to 806 students in grades four through twelve, from various urban and suburban settings in the greater Boston area.

From the data collected in this survey, reliability was assessed according to several approaches including the Spearman-Brown, Flanagan, and Gutman split-half correction formulas resulting in a reliability range from 0.91 to 0.94 indicating a clearly satisfactory and acceptable reliability in comparison to similar instruments.

Readability for the attitude inventory was determined to be at approximately the eighth grade level overall according to calculations using Fry's Readability Index.

REFERENCES

Combs, A. W. Affective Education or None at All. National Conference on Affective Education, Chicago, Illinois: May 1971.

Kozlow, M. J., and Nay, M. A. "An Approach to Measuring Scientific Attitudes." Science Education, 1976, 60: 147-172.

Krathwohl, D. R.; Bloom, B. S.; and Masia, B. B. Taxonomy of Educational Objectives, Handbook II: Affective Domain. New York: David McKay Company, 1964.

Likert, R. "A Technique for the Measurement of Attitudes." Archives of Psychology, 1932, 140.

Newton, D. P. "Attitudes to Science." School Science Review, December 1975, 57: 368-371.

Payne, D. A. The Assessment of Learning: Cognitive and Affective. Lexington, Mass.: D. C. Health and Company, 1974.

Session L-1

ATTITUDES OF PRESERVICE ELEMENTARY SCHOOL TEACHERS TOWARD SCIENCE TEACHING: ANTECEDENTS AND RESPONSE TO FIELD EXPERIENCE

Joseph C. Cotham
Indiana University
Bloomington, Indiana 47405

Rationale And Objectives

An important goal of elementary science teacher education is the development of positive attitudes toward science and science teaching. As suggested by Stollberg (1969), teachers with neutral or negative attitudes may avoid teaching science and may pass their negative attitudes along to their students.

Establishing relationships between attitudes and potential antecedents would provide a basis for effective modification of these attitudes in instruction for preservice science teachers. Shrigley (1974) investigated four potentially significant antecedents to science and science teaching attitudes. They were:

1. Effect of sex difference:
2. Effect of male elementary science teachers;
3. Effect of organized and incidental elementary science programs; and
4. Effect of the number of high school science courses.

In the sample studied by Shrigley only the effect of the number of high school science courses and the effect of organized elementary science programs significantly influenced attitude about science and science teaching. The first purpose of this research was to replicate and extend Shrigley's study of potentially significant antecedents to attitudes about science and science teaching. In addition to the variables studied by Shrigley, the effect of activity-oriented elementary science instruction was investigated.

Substantial educational work has been done with preservice teachers to change their attitudes toward science and science teaching through modification of science methods courses (DeVito and Nordland, 1974; Thompson and Thompson, 1975; and Sunal, 1980). Field experience has increasingly become a part of professional programs, and its effect on teacher education outcomes is, therefore, of considerable interest. Sunal studied the effect of field experience on a variety of preservice teacher variables including attitude. A second purpose of this study was to contribute to research on the effect of science teaching field experience on preservice elementary school teachers' attitudes about science and science teaching.

Summary of Methods and Results

Subjects for this study were 94 preservice elementary teachers drawn from two elementary science methods courses, a "traditional" course with a small field experience component and a recently implemented course that incorporates

a major field experience emphasis. Shrigley's Science Attitude Scale (alpha= .91) was administered as a pre-test and post-test to both groups. An instructor-generated background questionnaire was used to gather data from participants in the study on the potential attitudinal antecedents under investigation. The effect of potential antecedents on attitudes was analyzed using two-tailed t-tests. Group comparisons were made using a one-way analysis of covariance with two levels of field experience and pre-test as covariate. The results of these analyses will be discussed, including possible rival hypotheses and the educational implications of the results.

REFERENCES

DeVito, A. and Nordland, F. "Unifying, Simplifying, and Humanizing Science Preparation of Prospective Elementary Teachers," Unpublished paper, Purdue University, 1974.

Shrigley, R. L."Science Attitudes of Preservice Elementary Teachers." School Science and Mathematics , 1974, 74: 243-250.

Stollberg, R. "The Task Before Us-1962. The Education of Elementary School Teachers in Science." Reprinted by L.I. Kuslan and A. H. Stone in Readings on Teaching Children Science. Belmont, Calif.: Wadsworth Publishing Company, 1969.

Sunal, D. W. "Effect of Field Experience During Elementary Methods Courses on Preservice Teacher Behavior." Journal of Research in Science Teaching, 1980, 17: 17-24.

Thomson, R. G. and Thompson, A. G. "Building Attitudes Toward Science for Preservice Teachers: An Experiment." School Science and Mathematics, 1975, 75: 213-216.

Session L-2

THE EFFECTS OF A MODIFIED MASTERY LEARNING STRATEGY ON ACHIEVEMENT, ATTITUDES, AND ON-TASK BEHAVIOR OF HIGH SCHOOL CHEMISTRY STUDENTS

F. Gerald Dillashaw
Bethany College
Bethany, West Virginia 26032

James R. Okey
University of Georgia
Athens, Georgia 30602

Purpose/Objective

Research has shown that Bloom's (1971) mastery learning strategy can be used to improve achievement. Mastery learning is characterized by frequent diagnosis of learner difficulties with remediation based on the results of diagnostic quizzes. The cycle of diagnosis-remediation is repeated until students master instruction. Remediation exercises may be specified by teachers or selected by students.

However, the logistics of operating a full-fledged mastery learning strategy may deter teachers from doing so in spite of documented achievement gains. In this study, mastery learning was modified to limit diagnosis and remediation to two cycles. The study explored the effects of this limited diagnosis-remediation strategy on achievement, attitudes, and on-task behavior of high school chemistry students. A growing body of research indicated that on-task behavior (i.e., the time students actually spend learning) is highly correlated with achievement.

The personal variables, locus of control, and aptitude, were also studied in this investigation to determine their relationship to achievement, attitudes, and on-task behavior. Research shows that aptitude and locus of control may moderate student outcomes in different instructional settings.

Procedure

Three treatment groups were included in the study: (1) a contrast group (no diagnostic-remediation procedures); (2) a student-managed remediation group (students selected their own remediation following diagnosis); and (3) a teacher managed remediation group (teachers assigned remediation based on diagnostic test results). Three first-year high school chemistry classes were randomly assigned to each of the three treatment levels. A total of 156 students in the nine classes were stratified on three aptitude levels (high, average, and low) and two locus of control levels (internal and external). The treatment lasted for 45 instructional days. Three cognitive achievement measures, an attitude quesitonnaire, and an on-task observation instrument were used to test hypotheses.

Results

The effect due to treatment was consistently significant across the three cognitive achievement measures and the on-task measure. The modified mastery groups significantly outscored the contrast group on all achievement measures. No significant differences due to treatment were noted for the attitude

measures and no significant main effects due to locus of control were found. A significant main effect due to aptitude was noted for on-task behavior: the low aptitude students exhibited higher on-task behavior than average students. Trend analysis indicated that the mastery learning groups increased on-task behavior over time compared to the contrast group.

Conclusions

To be able to link teaching strategies with student outcomes is important. Results from this study show that the modified mastery learning strategy influenced on-task behavior and achievement. These results indicate that high school chemistry teachers may successfully employ such a strategy to increase on-task behavior and achievement. The lack of significant differences between the two experimental groups suggests that assigned remediation may not be necessary to bring about achievement gains; simply having remediation available for students to use on their own may be sufficient. As the study progressed, the on-task behavior of the experimental groups increased while that of the contrast group decreased. This finding of increased on-task behavior associated with mastery learning is especially noteworthy.

REFERENCE

Bloom, B.S., Hastings, J. T. and Madaus, G. F. Handbook on Formative and Summative Evaluation of Student Learning. New York: McGraw-Hill Book Company, 1971.

Session L-2

THE EFFECTS OF PROBLEM SOLVING TRAINING IN SCIENCE UPON UTILIZATION OF PROBLEM SOLVING SKILLS IN SCIENCE AND SOCIAL STUDIES

Terry Shaw
Kansas State University
Manhattan, Kansas 66506

Objectives and Purpose

This study is concerned with determining the effect of a process-oriented science curriculum upon the ability of sixth-grade students to utilize the process skills of controlling variables, forming hypotheses, interpreting data, and defining operationally. For the purpose of this study these four process skills were defined as problem-solving skills. Other areas investigated include: (1) determining if problem solving ability learned in science will transfer to social studies; and (2) testing models concerning problem solving skills in order to determine if there is evidence for a hierarchy of problem solving skills.

Methodology

Subjects were randomly assigned to treatment and control groups in this study. The treatment consisted of twenty-four weeks of activities from Science...A Process Approach (SAPA II). The control group participated in investigator-designed process-oriented activities covering the same subject matter area and incorporating the same amount of hands-on activities as the treatment group. At the end of the twenty-four weeks, two investigator-designed, process-oriented instruments were administered, one in science and one in social studies content area.

Results and Conclusions

A t-test was employed to test for differences between the mean score of the control and treatment groups on the science and the social studies instruments. The treatment group scored significantly higher on the problem solving skills portion of both the science and social studies instruments indicating that problem solving skills can be taught by the process-oriented science curriculum and that these processes will transfer to social studies content. No significant difference was found between the two groups on either instrument for the basic processes, with one exception. The treatment group scored significantly higher than the control group for the process of classifying on the social studies instrument, but not on the science instrument. Evidence was found to support the hierarchy model of process skills, strongly suggesting that mastery of the basic skills is a prerequisite to proficiency in the problem solving skills.

Session L-2

STRATEGIES USED BY HIGH SCHOOL STUDENTS WHEN SOLVING GENETICS PROBLEMS

James Stewart
University of Wisconsin
Madison, Wisconsin 53706

The study to be reported during this presentation was undertaken using the conceptions and data gathering techniques of cognitive (information processing) psychology. Individuals in this field, beginning with the work of Newell and Simon (1972) have made major advances in the study of human problem solving.

The following question was addressed in this study:

How does the conceptual knowledge of genetics possessed by high school biology students influence the strategies they use when solving three types of genetics problems? A case study approach was used in which students were asked to "think aloud" as they solved the problems.

The findings indicated that:

1. Even though most students could solve most problems, many were doing so in a non-meaningful fashion, e.g., they were applying an algorithm without connecting the algorithm to genetics conceptions.
2. The use of alegbraic, rather than Punnett square methods for solving problems apparently interfered with students connecting what they were doing to meiosis.

The significance of these and other related findings stem from the vast number of students who receive genetics instruction and from the central role that genetics has in modern biology. The knowledge gained could be used to alter instruction so that meaningful problem solving in genetics may be enhanced.

REFERENCE

Newell, A. and Simon, H. A. Human Problem Solving, Englewood Cliffs, New Jersey: Prentice-Hall, 1972.

Session L-3

RESEARCH AND THE CRISIS IN SCIENCE EDUCATION

Joseph Lipson
Robert Watson
Rita W. Peterson
Kathleen M. Fisher
National Science Foundation
Washington, D.C. 20550

The purpose of this symposium is to discuss the current status of research in science education within a context of the national and international needs in science education.

There are a variety of social indicators that indicate a gradually rising concern with the state of science education. These include the following:

1. Comparisons with other countries such as Japan, West Germany, and Russia have attracted increasing media and government attention.
2. Data regarding the state of students' knowledge and skill in science, math, and technology at all levels has given rise to concern both on an absolute basis (i.e., things that most students should know and don't) and on the basis of comparision between groups (e.g., blacks vs. whites, women vs. men, etc.). Data include results from the National Assessment of Educational Progress, SAT, and other studies (e.g., Armed Forces studies).
3. Evidence from recruitment and training of people for skilled positions involving science and technology reveals a serious and growing problem.
4. The general public response to technological change suggests the need for greater understanding of science, its methods, and limitations.
5. Imbalances in the percentages of women and minority members in various academic programs and in scientific and technological careers suggests a failure of the science education system (which may also link to conditions beyond the science education system).

Any attempt to engage in massive action programs without a deeper understanding of the factors involved is liable to be counterproductive. The kind of research needed to contribute to the long-range solution of the condition will be briefly discussed.

The RISE Program, Research in Science Education, at the National Science Foundation supports fundamental research about learning and teaching of science and mathematics. Recently it has focused especially on theoretical and

empirical research dealing with: (1) factors that may specifically influence learning of science and mathematics during adolescence; (2) factors that affect the participation of women, minorities, the gifted, and the physically handicapped in science-related activities; (3) the way the new educational technologies affect cognitive development in science; (4) science literacy and the interface between science and society; and (5) the relationship between learning precesses and the structure of scientific and mathematical knowledge.

This presentation will describe the major directions taken by RISE-supported researchers during the past year, identify some interesting gaps within the field of research currently underway, and suggest some promising new avenues for future research.

Finally, following this introduction to the National Science Foundation and its mission, major funding units will be identified, with special reference to the program of the Directorate for Science Education. Current and future budget projections will be given.

All regular grant proposals to the National Science Foundation must be given review and evaluation by knowledgeable persons related to the proposed activities. The staff will discuss the various mechanisms used to review proposals, and explain how final decisions regarding support are reached.

Session L-4

THE RELATIONSHIP BETWEEN SCIENCE PROCESS SKILL AND FORMAL THINKING ABILITIES

Michael Padilla
James R. Okey
University of Georgia
Athens, Georgia 30602

F. Gerald Dillashaw
Bethany College
Bethany, West Virginia 26032

Purpose/Objective

The science process skills have been a prominant part of science curricula for some years. Emphasis on the integrated process skills (hypothesizing, identifying and controlling variables, defining operationally, interpreting data, and experimenting) is seen in such programs as ISCS, BSCS, and CHEM Study. Developing more recently has been an interest in formal operational thinking abilities (identifying and controlling variables, correlational thinking, combinatorial logic, and proportional logic) as described by Piaget.

A logical relationhip between process skill and formal operational abilities seems reasonable. The integrated process skills are involved when conducting experiments--one must formulate a hypothesis, design the experiment, and make generalizations after collecting the data. The ability to identify and control variables as described by Piaget involve precisely the same steps in problem solving. Other similarities exist, for example, experiments in science classes may involve proportional reasoning or correlational thinking in data interpretation. Despite strong similarities between process skill and logical thinking abilities, little research has been done to investigate this relationship.

The purpose of this study was to examine integrated process skill and formal thinking abilities of middle and high school students and determine the relationship, if any, between the two.

Procedures

Middle and senior high students completed two tests. The Test of Integrated Process Skills (TIPS) provided a measure of their integrated science process skill ability and the Test of Logical Thinking (TOLT) provided scores on the students' logical thinking skills. The instruments had been especially developed to assess process skill and logical thinking ability and had previously been shown to be valid and reliable.

Approximately 80 students were selected from each grade level from grades seven through twelve (N=492). Students were carefully chosen to provide the full range of ability levels. Students completed the two measures in a group setting (administered by their teachers) on two consecutive days.

Each of the two tests was analyzed to provide five subtest and total test scores. The scores (six for each instrument) were correlated to examine relationships between broad measures of process skill and logical thinking ability (total test scores) and facets of each ability (subtest scores). Test reliabilities were used to correct all correlations for attenuation.

Results

The correlations of the subtest of each test (TOLT subtests were proportions, identifying and controlling variables, probability, correlations, and combinations; TIPS subtests were hypothesizing, identifying variables, operationally defining, designing investigations, and graphing and interpreting data) were all significant ($p \leq .0001$) and ranged from .41 to .87 with most falling in the .50 to .65 range. The intercorrelation between total TIPS and total TOLT was .73 ($p \leq .0001$). The process skill subtests when correlated with the total TOLT score showed exceedingly high interrelationships ranging from .51 (identifying variables) to .99 (designing investigations). In addition, a factor analysis of the scores (promax rotated) was performed which identified one common factor which accounted for 37.4% of the total variance. Each subtest of both TIPS and TOLT correlated from .50 to .71 with the single factor.

Conclusions and Implications

These results indicate that formal thinking and process skill abilities are highly interrelated. The degree to which formal thinking abilities can affect mastery of process skills or vice versa needs further study. Given the prominent role of each topic in science education, this further study should be given high priority.

Session L-4

THE EFFECT OF SCIENCE TEACHING ON THE FOURTH GRADE CHILD'S CONCEPT OF PIAGETIAN PHYSICAL CAUSALITY

Louise L. Gann
Alcoa Elementary School
Alcoa, Tennessee 37701

H. Seymour Fowler
The Pennsylvania State University
University Park, Pennsylvania 16802

The purpose of the present study was to investigate the effect of selected science experiences on the students' concepts of Piagetian physical causality. Fourth-grade children served as subjects. The specific Piagetian causal concepts tested were animism and dynamism.

The independent variables of vocabulary ability and Piagetian developmental stage were assessed through the use of the Concept Assessment Kit Conservation (Form A) and the Metropolitan Achievement Test (Form F). Students were randomly assigned to four home-room teachers prior to the testing. Groups two and four were chosen for the experimental group.

Three-hundred minutes were devoted to instruction during the treatment phase of the study with the first 150 minutes devoted to teaching the cause of floating to the experimental group. The second 150 minutes was devoted to the teaching of the definition of the term "living."

The control group was given 300 minutes of language arts instruction as a placebo. All lessons used were evaluated by the fourth-grade teachers working with the students in the other subject areas.

Post-testing was conducted upon completion of the treatment phase. The Concept Assessment Kit Conservation (Form A) was readministered for the purpose of identyifying those subjects who had changed from one developmental stage to another. A change in developmental stage was considered an independent variable during the analysis of the data. The dependent variable of causal stage was assessed by means of two clinical interviews. The first interview dealt with students' concept of "living," while the second considered the students' concept of the cause of floating.

Analysis of the data revealed a number of significant findings. Generally, experimental group performance was significantly superior to control group performance. In some cases, gender was a significant factor between groups and variables. Data for each clinical interview tended to follow a similar pattern.

Overall differences between experimental and control groups were significant ($p \leq .001$). However, significance was not as strong for females as for males.

Males and females in the experimental group did not differ significantly for living, according to chi-square analyses, but they did differ significantly ($p \leq .05$) for floating. Experimental and control group females did not differ

significantly. Control males and experimental males differed from control females and experimental females. All differences favored the experimental group, especially the males.

Significant differences were found in the use of causal relation of animism and dynamism when the independent variables of vocabulary and state of development were considered.

It was concluded from the results of this study that causal relationships of animism and dynamism could be taught to fourth-grade children. Those children who were classified as concrete operational had acquired the necessary cognitive structures to conserve, do reversible thinking, and make multiple comparisons.

Session M-2

THE DEVELOPMENT OF AN INQUIRY PRACTICAL EXAMINATION FOR UPPER ELEMENTARY CHILDREN

Edward L. Smith
Michigan State University
East Lansing, Michigan 48821

Problem

The goals for elementary science teaching are generally agreed to include both conceptual and process learning. However, commonly used multiple choice achievement tests tend to be biased against science programs which emphasize process and in-depth concept learning rather than breadth of topical coverage. One potential solution to this problem is the development and use of inquiry practical tests. In such tests, students engage in first-hand investigations in a stepwise manner. They are provided with information which enables them to continue even if they are unable to perform some aspects of the investigation.

Purpose

The purpose of the study reported here was to adapt the inquiry practical examination approach for use in the upper elementary school. In particular the objectives were to:

1. Develop an inquiry practical test for use with the SCIS sixth-grade Ecosystems unit;
2. Develop response analysis procedures to reflect students' performance on special inquiry tasks;
3. Apply the test in assessing childrens conceptual and process knowledge in relation to intended outcomes of parts of the Ecosystems unit;
4. Develop analysis procedures to characterize the conceptions underlying students' responses; and
5. Evaluate the test in terms of the utility of its results and its technical adequacy.

Methods

The design of the test was based on an analysis of the conceptual content and science inquiry tasks addressed in Part 3 of the SCIS Ecosystems unit. Two problems were selected which (1) required children to perform similar inquiry tasks; (2) provided opportunities to apply important concepts and propostions from the unit; and (3) differed in significant ways from those encountered in the unit.

The children proceeded through the investigations in a series of steps including:

1. Reporting of preliminary results;
2. Stating and justifying an hypothesis;
3. Designing an experiment, predicting a result, and justifying the predition; and
4. Carrying out an experiment, observing and interpreting the results, and justifying the interpretation.

Each child's work was collected and information provided as each step was completed. The testing of thirty-three children was completed in two sessions of about one hour each.

The tryout sample consisted of two sixth-grade classes (N=17;16) taught by a single teacher. The children were representative of the disctrict, an urban district with a large blue-collar population and Black and Latino minorities.

Student responses were analyzed using a scheme which assigned numerical codes to each response category allowing description of individual task performance as well as computation of scores. The conceptions analysis identified patterns of propositions derived from student responses. Reliability and validity were examined by comparing performance on the two problems and comparing performance on this test with performance on other tests also administered to the same children.

Results

Among the findings are:

1. About 25% of the children reflected the intended conception of gas exchange in plants and animals while others held partial or alternative conceptions.
2. Most children who had a consistent conception of gas exchange designed an experiment relevant to an hypothesis, but only 10% provided an adequate control.
3. There was about 70% agreement between the two problems as to the children's ability to design an experiment relevant to an hypothesis.

Conclusion

The inquiry pratical test appears feasible for use at the upper elementary level, provides highly useful information, and has adequate technical characteristics.

Session M-2

THE DEVELOPMENT OF A TEST INSTRUMENT FOR MARINE KNOWLEDGE OF ADULTS IN NORTHERN NEW ENGLAND

Wesley H. Hedlund
John W. Butzow
University of Maine at Orono
Orono, Maine 04469

Need for the Study

There are two principal justifications for producing a marine education instrument for adults. The first is a theoretical one. In producing this instrument, major concepts of marine education will be identified and an attempt to answer the following question will be made: How can marine education be operationally defined and broken down to its components? The second is a practical justification. There is simply no other instrument available for marine knowledge and attitudes of adult decision makers.

This study will attempt to answer the following questions:

1. Can a taxonomy of objectives for marine education be developed?
2. Can a valid and reliable instrument be developed to measure knowledge of the marine world?
3. Are there differences of marine knowledge on certain independent variables as age, sex, educational background, geographical area, and experience?

Procedure

This instrument development necessitated the recognition of the conceptual field of marine education. This was accomplished from identifying concepts in other statements and studies: (Goodwin (1976, 1977); Fortner (1978); Stegner and Greens, 1974); Lanier (1980); and other nationally recognized marine educators whose material is available through the Marine Educational Materials System (MEMS). A list of concepts and objectives was developed and rated for applicability by other marine educators (members of the Gulf of Maine Marine Education Association and other experienced marine educators). Concepts will be added or deleted. From the objectives list an item pool of 100 questions encompassing the cognitive domain was constructed. Test questions were judged and rated for content validity by a team of marine educators. The test was then administered on a trial basis to a sample of adults (N=500) drawn from general education classes at the UMO Evening Session (1980) and other evening school programs in Maine. Reliability, item discrimination, and difficulty were computed. A coefficient of equivalence was computed by using the split-half technique. The internal consistency was computed using the KR #20 test. Item difficulty and discrimination information were computed for each item as well.

REFERENCES

Fortner, R. W., Experiences Related to Oceanic Knowledge and Attitudes of Tenth-Grade Students in Virginia. Doctoral Dissertaion, Virginia Polytechnic Institute and State University, June, 1978. ERIC (ED 159 023).

Goodwin, H. L. "Perspective on Sea Grant Marine Education." Report of Proceedings of the workshop on Sea Grant marine education held at the Virginia Institute of Marine Science at Williamsburg, VA April 21 and 22, 1976.

Goodwin, H. L. "Notes for People of a Water Planet." In H. L. Goodwin (Ed.), Americans and the World of Water. Newark, Delaware: A Sea Grant Publication, 1977.

Lanier, J. "What Should Marine Educators Teach? Results of a Large Scale Delphi Study." Paper presented at the 1980 Annual Conference of the National Marine Education Association, Salem MA, August 8, 1980.

Stegner, R. W., and Greens, M. "A Conceptual Scheme for Marine and Coastal Environmental Studies" Project COAST, Marine Environment Curriculum Study, University of Delaware, 1974.

Session M-2

AN ANALYSIS OF RESEARCH STUDIES UTILIZING "HOME-MADE" ACHIEVEMENT INSTRUMENTS

Jean Hastings
James Stewart
University of Wisconsin
Madison, Wisconsin 53706

The presentation will have as its focus a problem described by Anderson (1972), namely, the quality of the construction and reporting of research that contains "home-made" achievement tests.

The current status of homemade achievement tests was examined in this study. Research reports in two science education journals were analyzed, using Anderson's eight categories of information that a high quality research report should include. The journals examined were Journal of Research in Science Teaching and Science Education from January 1975 to January 1980.

The findings indicate that reliability estimates and the procedures for selecting test items were mentioned more frequently in the science education journals than in Anderson's study. However, there was little or no improvement in describing the relation of test items to instruction.

These findings should be of interest both to researchers who are utilizing "home-made" achievement tests in their studies and to journal panels who are reviewing studies for publication.

REFERENCE

Anderson, Richard C. "How to Construct Achievement Tests to Assess Comprehension." Review of Educational Research, 1972, 42(2): 145-170.

Session M-3

REASONING PATTERNS OF COLLEGE LEVEL SCIENCE STUDENTS

George J. Pallrand
Michael D. Piburn
David Van Harlingen
Walter Lockwood
William Martin
Rutgers University
New Brunswick, New Jersey 08903

College represents a period of abrupt adjustment for many. This is particularly true for students in science and engineering programs. Materials presented are increasingly quantitative and abstract. These intellectual demands bring to mind Piaget's distinction between formal and concrete thought. At the formal level one is able to deal with relationships between propositions and not just objects as is the case at the concrete level. The formal thinker possesses the ability to make inferences (Inhelder and Piaget, 1958). What cognitive structures are needed to function at this level?

Conditional reasoning provides a useful paradigm with which to examine this question. The material implication (CON) or the if--then operator is fundamental to the hypothetical deductive process that characterizes science (Hempel, 1966). Kodroff and Roberge (1975) and Ennis (1971) have studied young children's ability to affirm the antecedent. Wason and Johnson-Laird (1972) among others, have studied adolescent's ability to make CON interpretations. The work of Taplin, Staudenmayer, and Taddonis (1974) represents a summary of the sequence of development of conditional reasoning. Children of third-grade treat CON statements as if they were conjunctions (CJ). They link the antecedent and consequent of a propositional statement in an associative manner, failing to recognize instances that are implied. Inferred instances are utilized by individuals of junior high age in making biconditional (BIC) interpretaions. By high school age some begin to recognize the asymetrical character of the antecedent and consequent in CON statements. Staudenmayer and Bourne (1977) argue that recognition of the asymmetry between the antecedent and consequent when they appear as the second premise in the syllogism requires the integration of two truth table contingencies into one response evaluation--and as such represents a test of formal, inferential reasoning.

The interpretative responses of undergraduate students to conditional statements were investigated by administering a propositional logic test (PLT) to approximately 500 undergraduate students enrolled in an introductory university level physics course. Slightly more than half of the BIC and CON statements were interpreted correctly. Approximately 20% of the responses to the BIC and CON items utilized the CJ pattern. Another 10% of the responses utilized an affirming pattern. Clinical interviews were conducted revealing an unusual fixation on the initial attribute. Approximately 57% of the BIC and CON items were correctly interpreted. On the BIC items, approximately 10% of the patterns made an incorrect CON interpretation. Similarly, on the CON items, 10% of the response patterns made were incorrect BIC interpretations.

The correct interpretation of the BIC and CON statements correlated with physics achievement by factors of .31 and .39 respectively. This relationship assumes additional meaning when the number of inferred instances correctly interpreted are plotted against grades. At the C+ grade point there is a pronounced increase in the slope of the graph. Higher grades are associated with the greatest use of correct inferred instances. This data suggest that the availability of operations involved in conditional or inferrential reasoning are necessary but not sufficient factors for above average achievement in college level physics. Those possessing these abilities are much more likely to succeed in such courses at a higher level.

REFERENCES

Ennis, R. H. "Conditional Logic and Primary School Children: A Developmental Study." Interchange, 1971, 2: 126-132

Hempel, C. Philosophy of Natural Science. Englewood Cliffs, New Jersey: Brentue Hall, 1966.

Inhelder, B., and Piaget, J. The Growth of Logical Thinking From Childhood to Adolescence. New York: Basic Books, 1958.

Kodroff, J., and Roberge, J. J. "Conditional Reasoning Abilities of Primary Grade Children." Developmental Psychology, 1975, 11: 21-28.

Staudenmayer, H., and Bourne, L. A. "Learning to Interpret Conditional Sentences: A Developmental Study." Developmental Psychology, 1977, 13: 616-623.

Taplin, J. E., Staudenmayer, H., and Taddonis, J. L. "Developmental Changes in Conditional Reasoning: Linguistic or Logical?" Journal of Experimental Child Psychology, 1974, 17: 360-373.

Wason, P. C., and Johnson-Laird, P. N., Psychology of Reasoning: Structure and Content. Cambridge, Mass.: Harvard University Press, 1972.

Session M-5

SCIENCE EDUCATION: ACCOMPLISHMENTS AND NEEDS

John W. Renner
University of Oklahoma
Norman, Oklahoma 73109

Robert E. Yager
University of Iowa
Iowa City, Iowa 52242

James J. Gallagher
Michigan State University
East Lansing, Michigan 48823

Ertle Thompson
University of Virginia
Charlottesville, Virginia 22903

This is an analysis of agreements and disagreements with major statements in the NSTA working paper by the same title. A hundred-person leadership group was selected by the presidents of NARST, AETS, NSSA, NSTA, and CESI for securing perceptions of the paper. This report is an analysis of more than forty ideas that were identified as a rationale for science education late in the 1970's, an enumeration of accomplishments, a statement of current needs, and recommendations for the future. Levels of agreement and disagreement are presented; new ideas prepared by its fine group of leaders are added. The report ends with a synthesis of the ideas concerning the accomplishments in science education during the 1960-80 period, an analysis of current needs, and recommendations for future actions.

GENERAL SESSION IV

CONSIDERATION OF TYPES OF ERRORS IN SCIENCE EDUCATION RESEARCH

Arthur L. White
The Ohio State University
Columbus, Ohio 43210

Abraham, Michael R. 7, 89
Adams, Wenda J. 94, 97, 100
Anderson, Charles W. 158
Anderson, Ronald D. 21

Baird, J. Hugh 108
Baker, Dale R. 27
Barufaldi, James P.. 119
Bell, Paul E.. 167
Berson, Garth D. 79
Berger, Carl F.. . . . . 93, 137
Betkouski, Marianne. 102
bin Abdullah, Kemal. 4
Birnes, Beverly. 26
Botti, James A. 121
Bowver, Jane 136
Butts, David P. 52, 107
Butzow, John W. 194
Bybee, Rodger. 58, 60

Camp, Carole Ann 165
Capie, William 13, 15, 17, 175
Carbonara, David D.. 82
Chiappetta, Eugene L.. 24
Cohen, Herbert G. 160
Cotham, Joseph C. 180
Crow, Linda W. 176

DeMelo, Hermes T.. 163
DeTure, Linda. 36
Dillashaw, F. Gerald 171, 182, 188
Dobey, Daniel 65
Doody, William 65
Douglas, Claudia 36
Dowling, Kenneth W.. . . . . 23, 59
Duffy, Michael 134
Dunlop, David L. 148
Dwyer, Francis 163
Dyer, Gloria J.. 169

Ellis, James D.. 157
Enyeart, Morris A. 72, 77

Farmer, Walter A. 70
Farragher, Pierce. 145
Fazio, Frank 148
Finley, Fred N. 48, 154
Finley, John 132
Fisher, Kathleen M. 186
Fowler, H. Seymour 106, 121, 125, 190
Fraser-Abder, Pamela 125

Gabel, Dorothy L. 111
Gabel, Lawrence L. 110
Gallagher, James J. 199
Ganiel, Uri. 87
Gann, Louise L. 190
Glass, Gene V. 21
Grant, Rosalie 129
Green, Mildred R. 33

Harmon, David J. 36
Hassan, Ahmed Khalil Mohamed 90
Hastings, Jean 196
Haukoos, Gerry 86
Hedlund, Wesley H. 194
Helgeson, Stanley L. 110
Helseth, Edwin A. 94, 97, 100
Hewson, M. G. 25
Hofstein, Avi. 87
Holliday, William G. 79
Hrabal, Edward T. 47

Issacs, Patricia A. 6

Jones, Dan R. 146
Jones, Edward E. 53

Kahl, Stuart R. 21
Karplus, Robert 136
Kelsey, Linda J. 84
Kielbowick, David P. 81
Kilbourn, Brent. 124
Koballa, Thomas R., Jr. 173
Koran, John J., Jr. 1, 2, 3
Koran, Mary Lou 2, 3
Kushner, William S. 113

Lamb, William. 102
Lawson, Anton E. 104
Lazarowitz, Reuven 108
Lehman, Jeff R.. . . . . 2, 3
Leonard, William H.. 140
Linn, Marcia C.. . . . . 26, 136
Lipson, Joseph 186
Lockwood, Walter 73, 197
Lombard, Anne 150
Loughner, Helen M. 43, 45
Lowell, Walter E.. 5
Lutz, John E.. 83

Martin, William. 73, 197
Mattheis, Floyd E. 23
Matthews, Charles C. 115, 117
Mayer, Victor J. 127
McKenzie, Danny L. 19
McNeill, Constance T.. 107
Merkle, Dale G.. 32
Miller, P. Ann 12
Mondrinos, Veronica. 30
Moser, G. W. 42, 43, 45, 47
Munby, Hugh 138
Munyer, Edward A.. . . . . 1, 2, 3

Newton, Roger 13, 15, 17
Novak, John A. 142

Okey, James R. 171, 182, 188
Orpwood, Graham W. F. 38

Padilla, Michael 19, 188
Pallrand, George J.. . . . . 75, 197
Penick, John E. 58, 86
Peterson, Rita W. 186
Pezaro, Peter E. 37
Piburn, Michael D. 72, 77, 197
Piper, Martha K. 176
Pizzini, Edward L. 59
Porter, Charles F. 171
Pulos, Steven 26, 136
Purnell, Charlotte 59

Ray, Charlie L.. . . . . 115, 117
Renner, John W.. . . . . 7, 71, 199
Riley, Joseph P., II 152
Ritz, William C. 23
Roberts, Douglas 41
Robinson, James T. 51
Rojas, Carlos A. 127
Rojas, Ninoska R. 134
Rojas, Pastor R. 134
Rothaug, Walter. 75
Rudy, Marcia Kaplan. 63
Russell, Thomas L. 8

Schellenberg, John P. 167
Schlitt, Dorothy 115, 117
Sellers, Burt A.. 61
Shafer, Lynn D. 2, 3
Shaw, Terry. 184
Sherris, Jacqueline D. 55
Sherwood, Robert D. 57, 111
Shymansky, James A. 67
Sindhikara, Jean 131
Sipe, H. Craig 34
Smith, Edward L. 192
Smith, Mary Lee. 21
Stage, Elizabeth K. 26, 136
Stanback, Bessie A. 10
Stewart, James 185, 196
Strawitz, Barbara M. 68
Sunal, Cynthia S.. 155
Sunal, Dennis W. 155
Swami, Piyush. 110
Szabo, Michael. 145, 163

Taylor, Cheri M. 132
Thier, Herbert D. 23
Thompson, Ertle. 58, 199
Tobin, Kenneth G. 13, 15, 17, 175
Trembath, Richard J. 119
Tulloch, Bruce 34

Van Harlingen, David 29, 75, 197
Voelker, Alan M. 50
Voss, Burton E. 142

Wallace, Charles W. 23
Wareing, Carol 178
Waterman, Margaret 168
Watson, Robert 186
Welch, Wayne W. 26, 130
Westerback, Mary 4
White, Arthur L. 36, 200
Willett, Richard E. 39
Willson, Victor L. 22
Wilson, John T. 123

Yager, Robert E. 59, 60, 199
Yarroch, William L. 154
Yeany, Russell 21, 94, 97, 100

Zehr, Eric E. 60
Zeitoun, Hassan H. 106
Ziccarelli, Gabriel M. 42